CHAPTER 5 .... TREATMENT 3

Chapter 5
Treatment

Any treatment process not specifically covered in Chapter 5 is likely considered New Technology and must follow the New Technology Approval Process (310 CMR 22.04(8) and DWP Policy 89-01).

5.1 General Information

5.1.1 Permits

Permit applications must be completed for all pilot proposals, pilot study reports, and final plans for water treatment and submitted to MassDEP for final approval.. All final design plans must be stamped by a professional engineer (P.E.) registered in Massachusetts in the appropriate engineering field and submitted to MassDEP for final approval. Inquiries regarding Drinking Water Program (DWP) permits should be directed to the appropriate regional office.

Permit applications and approvals may also be required from many non-DWP state programs such as waste handling and disposal (see Section 5.10). Inquiries regarding these types of programs should be directed to the appropriate regional office.

5.1.2 Engineer's Report

An initial engineering study documented in an engineer's report shall be submitted in conformance with Section 1.1, Engineer's Report.

5.1.3 Engineer's Plans and Specifications

Unless otherwise requested by MassDEP, it is only necessary to submit engineering plans and specification for the equipment and materials directly related to the treatment process(es). (See Chapter 1, Sections 1.2 and 1.3.) MassDEP requests one hard copy and one electronic copy of the appropriate specifications and plans. The electronic copy must be submitted on a compact disk or other acceptable media and must be in PDF format.

5.1.4 Pilot Studies

A pilot proposal and a pilot study or in-plant demonstration study shall be conducted when requested by MassDEP. Permits are required for both the proposal and the study. Both the proposal and the study must be conducted in accordance with DWP Policy 90-04.

5.1.5 Water Treatment Facility Design

General Information

1. Facility design shall:

   a. Include a minimum of two units for each unit process unless otherwise approved by MassDEP

   b. Consider a design that would permit operation of the rapid mix and flocculation tanks in either series or parallel

   c. Permit units to be taken out of service without disrupting operation and with drains or pumps sized to allow dewatering in a reasonable period of time

   d. Include multiple-stage treatment facilities when required by MassDEP

   e. Minimize hydraulic head losses between units to allow future changes in processes without the need for repumping

   f. Include space and equipment for operators to conduct all necessary process and operational procedures such as jar testing. Results shall be used at the plant to assure that chemical feeds are adjusted and maintained in response to raw water changes in temperature, turbidity and other variations in quality.

   g. Include equipment and connections for disinfection of all water treatment facilities that are taken out of service for inspection, repairing, painting, cleaning or other activity that might lead to contamination of water. Disinfection must be conducted in accordance with AWWA Standard C-653.

   h. Include a Waste Disposal Plan as described in Section 5.10.1.2

   i. Not propose siting within a 100 year floodplain except for intake structures.

   j. Include covered structures for all outdoor water treatment plant basins unless otherwise approved by MassDEP.

   k. Be designed and constructed in such a manner as to prevent contamination of the water supply, by excluding any cross connections to the distribution system and by-passes of treatment units through interconnection of chemical feed or other piping. At all facilities treating surface water, pre- and post-chemical feed systems must be independent to prevent possible siphoning of partially treated water into the clearwell.

   l. Include equipment, controls, and alarms for maintaining the facility in accordance with applicable standards to prevent trespassing, vandalism, and sabotage.

   m. Include weather resistant equipment where applicable and the appurtenances and equipment for maintaining the facility in good repair.

n. Include sufficient flow meters to allow for appropriate process control and determining a flow balance within the facility.

o. Indicate only chemicals proposed for use as chemical additions in the water treatment plant that have been thoroughly evaluated and approved by MassDEP. MassDEP may require the following as part of the evaluation: desk top study, bench scale study, pilot study, proposal, pilot testing, pilot report, or new technology approval.

p. Indicate those chemical feed systems which might adversely affect the public health or exceed a federal or state standard in the event of an overfeed, systems shall be equipped with an electrical interlock(s) with the production pump(s) and at least one of the following system appropriate overfeed prevention devices:

(1) Non mechanical type flow switch

(2) Flow pacing device

(3) Continuous pH analyzer with shut down capabilities

(4) Equivalent devices as approved by MassDEP

Note: Electrical interlock(s) systems may not be applicable and or effective for gravity flow systems unless otherwise approved by MassDEP, chemical feed systems shall also be equipped with audio and visual alarms to notify the operator of such events as described above. Chemical feed systems must have audio and visual alarms when operating in manual mode. Manual mode assumes operating in manual override[1.] At a minimum or as otherwise approved in writing by MassDEP, manual override mode operation shall initially activate a visual alarm and after a set period of time an audio alarm would be triggered. All alarms and interlocks on chemical feed systems shall be tested monthly or more frequently if so recommended by the manufacturers. Systems not equipped as specified above shall be retrofitted to have this equipment or capability as soon as possible or on a schedule as determined by MassDEP.

q. Provide for audio and visual alarms for any pump at a drinking water facility, which as determined by MassDEP may have the capability of significantly impacting the public drinking water system in an adverse manner when operating in manual mode. At a minimum or as otherwise approved in writing by MassDEP, manual mode operation shall initially activate a visual alarm and after a set period of time an audio alarm would be triggered. Pumps not equipped with above specified alarms shall be retrofitted with this capability as soon as possible or on a schedule as determined by MassDEP

Note: Only a certified operator or a designee under the direct supervision of the certified operator may set a pump, including chemical feed pumps, in manual mode.

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[1] A manual override is a procedure where an otherwise automatic system is switched to manual control, usually from a computer or other automatic control.

r. Ensure that all alarms at a drinking water facility including alarms for pumps, high water, intrusion, etc. are transmitted to a location that is manually monitored continuously. If no such location is available, suitable alternative arrangements shall be made such as a programmable telephone dialer to an on-call person or persons. Telemetry systems, such as programmable telephone dialers, shall include a local alarm at the monitored location in case of loss of the telephone line or radio communications failure or other transmission failure**.** All requirements in this section must be satisfied unless otherwise approved by MassDEP. Systems not equipped as specified above shall be retrofitted to have this capability as soon as possible or on a schedule as determined by MassDEP.

5.1.6 Final Requirements for the Treatment Facility

1. Before the treatment facility goes on-line, the following items must be completed:

    a. Determination of Compliance

    The water supplier shall submit a Determination of Compliance letter to MassDEP that certifies the following:

    (1) The facility is fully operational, tested, and ready to go on-line.

    (2) The facility was constructed in accordance with MassDEP's approval letter.

    (3) All conditions of approval have been met.

    (4) All chemicals used in treatment meet the requirements of the Guidelines.

    (5) The O&M manual has been prepared and staff has been trained in all O&M procedures.

    (6) The supplier shall provide a copy of the punch list as an attachment to the letter as well as timelines to complete the punch list items.

    (7) All alarms have been tested and are operating properly.

    b. Water Quality Tests

    In addition to the required monitoring to evaluate the efficacy of treatment, sampling must be conducted for volatile organic chemicals, inorganics (including lead and copper), bacteria, and secondary contaminants and if required by the regional office: radionuclides and synthetic organic chemicals.

    c. Operation and Maintenance Manual

    The O & M manual shall be prepared in compliance with DWP Policy 93-02; the manual shall be available at the facility at the time of final inspection and at all times after the facility is approved to go on-line by MassDEP. The PWS shall incorporate the following into the system's O&M manual:

(1) A stand-alone schedule of inspections, testing, and preventative maintenance recommendations shall be provided for all the components of the system.

(2) Calibration curves shall be provided for all chemical feed pumps.

(3) An annual or more frequent performance evaluation of all alarms and signals shall be conducted.

d. Operator Staffing Plan
The plan must comply with 310 CMR 22.11B.

e. As-Built Plans
These plans should be available on site once the facility is completed.

f. Final Inspection
The inspection shall be conducted by MassDEP or its designee. (refer to Policy # 88-19).

g. Written approval must be received from MassDEP to place the facility on-line.

2. Contact Time (CT) Tracer Study

When required by MassDEP, a contact time tracer study shall be conducted to determine available contact times (see Section 5.4.1.2). The study is needed to ensure that the Surface Water Treatment Rule (SWTR) requirement and all subsequent SWTR (i.e. Interim Enhanced Surface Water Treatment Rule (IESWTR), Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR), and Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)) requirements pertaining to disinfection contact times and inactivation of selected pathogens will be met when using a chemical disinfectant. The study will consist of the following:

a. A pilot proposal for the contact time tracer study

b. The actual piloting of approved tracers

c. Submittal of a pilot study report of the contact time tracer study

d. To satisfy the SWTR the pilot proposal must be approved by MassDEP prior to final approval for the water treatment plant to go on-line either as a new facility or as a retrofitted facility. Included in the pilot proposal must be the identification of interim values to be used at startup to insure that the facility will comply with the inactivation requirements of the SWTR. The permit process allows 60 days for the review and approval of the proposal (Permit BRP21-22).

e. Piloting, using approved tracer(s), will commence within 30 days of startup of the treatment facility. When piloting of the tracers has been completed, data will be incorporated into a pilot report on the contact time tracer study. The pilot report on the contact time tracer study shall outline the final methods and values the water system intends to use to comply with the SWTR.

f. The pilot study report of the contact time tracer study must be submitted within 60 days of commencing piloting as required by the permit process.

g. When using UV light for disinfection, the IT (ultraviolet light intensity X time) requirements for inactivation must be met (see Section 5.4.6).

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5.1.7 Optimization of Water Treatment Facility Performance

1. Water treatment facilities designed to comply with the requirements of the SWTR, ESWTR, LT1ESWTR and LT2ESWTR must be optimized continuously for water to be free of microbial pathogenic organisms such as *Giardia Lamblia*, *Cryptosporidium* and viruses. The following components should be incorporated into an optimization evaluation:

   a. Minimum Data Monitoring Requirements

      (1) Daily raw water turbidity

      (2) Settled water turbidity at 4-hour time increments from each sedimentation basin

      (3) On-line (continuous) turbidity from each filter

      (4) One filter backwash profile each month from each filter

   b. Individual Sedimentation Basin Performance Goals

      (1) Settled water turbidity less than 1 NTU 95 percent of the time when annual average raw water turbidity is less than or equal to 10 NTU

      (2) Settled water turbidity less that 2 NTU at 95 percent of the time when the annual average raw water turbidity is greater than 10 NTU

   c. Individual Filter Performance Goals

      (1) Filtered water turbidity less than 0.1 NTU at 95 percent of the time (excluding 15 minute period following backwashes) based on the maximum values recorded during 4-hour time increments

      (2) Maximum filtered water measurement of 0.3 NTU

      (3) Maximum filtered water turbidity following backwash of less than 0.3 NTU

      (4) Maximum backwash recovery period of 15 minutes (e.g., return to less than 0.1 NTU)

   d. Disinfection Performance Goal

      CT values shall achieve required log inactivation of Giardia, *Cryptosporidium* and viruses.

2. Continuous optimization of treatment plant performance to help insure control of pipeline corrosion so that the 90^{th} percentile lead and copper concentrations are minimized (below action levels of .015mg/L for lead and 1.3mg/L for copper) at the customer's tap.

3. Continuous optimization of treatment plant performance is required for removal of disinfectant by-product precursors and for control of disinfection by-products is required so that disinfection byproduct concentrations are minimized below the MCLs.

4. Continuous optimization of treatment plant performance is required to help insure that secondary water quality standards (or any aesthetic standard) are not exceeded. Optimization should include the minimization of aesthetic contaminants.

5. Operational flexibility is required to handle a variety of water quality situations; jar testing should be required on a regular basis.

6. Establishment and implementation of management protocols designed to help insure that the water treatment plant is continuously optimized to the fullest extent possible is required.

5.2 Clarification

5.2.1 Presedimentation

Waters containing high turbidity may require presedimentation either with or without the addition of coagulation chemicals. The feasibility and effectiveness of presedimentation should be specifically addressed in the engineer's report for review by MassDEP.

1. Basin Design
   Presedimentation basins should have hopper bottoms or be equipped with continuous mechanical sludge removal apparatus and provide arrangements for dewatering.

2. Inlet
   Inlets shall be designed to distribute the water evenly and at uniform velocities; short circuiting must be prevented.

3. Bypass
   Provisions for bypassing presedimentation basins shall be included.

4. Detention Time
   Two to four hours detention is the recommended time; longer or shorter detention may be required based on piloting or bench scale evaluations.

5.2.2 Rapid Mix

Rapid mix is the rapid and even dispersion of chemicals throughout the water to be treated, usually by violent agitation. The engineer shall submit the design basis for the velocity gradient

(G Value) selected, considering the chemicals to be added, water temperature, color, and other related water quality parameters.

1. Equipment
   Static or mechanical mixing devices may be approved along with any other method proven by piloting evaluations. Variable speed mechanical mixing devices should be considered.

2. Mixing
   The detention period should yield a velocity gradient of 600 to 1000 ft/sec/ft for mechanical mixing.

3. Location
   The rapid mix and flocculation basins shall be located as close together as possible.

4. Accessibility
   Each rapid mix basin or device shall be constructed for easy observation and access.

5. Chemical Feed
   Chemicals shall be applied at such points and by such means as to insure satisfactory mixing of the chemicals with the water. Preliminary design documents, submitted with the piloting report should contain diagrams of proposed application points of all chemicals.

5.2.3 Flocculation

Flocculation is the agitation of chemically treated water at low velocities for periods of time to encourage formation of floc particles.

1. Basin Design
   Inlet and outlet design shall minimize short-circuiting between flocculation and sedimentation basins and also prevent the destruction of floc. Basins shall be designed for sludge removal by dewatering, pumping, gravity drainage or other methods. For details on residuals removal see Section 5.10.

2. Detention
   Detention time for floc formation should be 20 to 30 minutes. Longer or shorter detention time may be allowed based on piloting.

3. Equipment
   Agitators shall be driven by variable speed drives with the peripheral speed of paddles or walking beam flocculator ranging from 0.5 to 3.0 ft/sec.

4. Piping
   Flocculation and sedimentation basins shall be located as close together as possible. The velocity of flocculated water through pipes or conduits entering settling basins shall not be greater than 1.5 ft/sec. To maintain floc, allowances must be made to minimize turbulence at bends and changes in direction.

5. Cleaning

A water supply of sufficient quantity shall be available in reasonable proximity to the flocculation and sedimentation basins.

6. Superstructure
A cover or enclosure over the flocculation basins may be required to protect against weather and contamination. A watertight access hatch should be installed to allow access and observation. Hatches should be sized to allow installation and removal of basin equipment components.

7. Accessibility
Each flocculation basin shall permit observation and easy access.

8. Safety
Permanent ladders or handholds should be provided on the inside walls of basins and shall comply with latest OSHA regulations. Guard rails should be provided for any floors or walkways adjacent to open basins.

9. Chlorine Feed
Installation of chlorine feed points in flocculation basins are recommended to allow for shock dosing for maintenance purposes.

10. Chemical Feed
Maintain the proper application of all chemicals required for meeting primary MCLs when a treatment plant is in operation.

11. Underwater Light
To assist in determining flocculant presence, effective size, and density, an underwater light should be installed in flocculation chambers approximately 12 inches below the normal water level of the basin.

5.2.4 Sedimentation

Sedimentation may follow flocculation. The detention time for effective sedimentation depends upon a number of factors related to basin design, hydraulic flows and the nature of the raw water. The following criteria apply to conventional sedimentation units:

1. Detention Time
Detention time for settling should be between 2 to 4 hours of settling time at maximum flow rate depending on raw water quality and pre-treatment chemistry. Reduced detention time may be approved if equivalent effective settling is demonstrated during piloting or bench evaluations.

2. Inlet Devices
Inlets to sedimentation basins shall be designed to distribute the water equally and at uniform velocities. Open ports, submerged ports, and similar entrance arrangements are required. Baffles should be constructed across the basin close to the inlet end and should project several feet below the water surface to dissipate inlet velocities and provide uniform flows through the basin.

3. Outlet Devices

Outlet devices shall be designed to maintain velocities suitable for settling in the basin and to minimize short-circuiting.

4. Weir Overflow Rate
   Recommended weir rates are not to exceed 20,000 gal/day/ft of weir length. A higher number will be considered where justified. Where submerged orifices are used as an alternate for overflow weirs, they should not be lower than 3 feet below the flow line with flow rates equivalent to weir loadings.

5. Surface Overflow Rate
   The overflow rate shall not exceed 800 gal/day/ft^2. Higher rates may be allowed based on evaluation of water quality settling characteristics and filter loading rates.

6. Velocity
   The velocity through sedimentation basins should be between 0.5 and 3.0 ft/min. The basins must be designed to minimize short-circuiting. Baffles may be provided as necessary to control velocities and short-circuiting.

7. Overflow
   An overflow weir (or pipe) shall be installed at an elevation above the maximum desired sedimentation basin height. Gravity discharge of overflow waters will be discharged or directed to reservoirs, lagoons or MassDEP approved locations.

8. Superstructure
   A cover or enclosure over the sedimentation basins may be required to protect against weather and contamination. A watertight access hatch should be installed to allow access and observation. Hatches should be sized to allow installation and removal of basin equipment components.

9. Residuals Collection
   Mechanical residuals collection equipment is recommended to prevent reintrainment of residuals. The residuals collection equipment should not disturb the settled solids. Acceptable collection means include traveling screens, sludge scrapers, or vacuum systems.

10. Residuals Removal
    Residuals removal design shall include:

    a. Sedimentation basin floors should be sloped to a central collection point or trough to facilitate drainage and residuals removal.

    b. Residuals removal should comply with general requirements of Section 5.10.

11. Flushing Lines
    Flushing lines or hydrants shall be provided and must be equipped with backflow prevention devices acceptable to MassDEP.

12. Safety
    Permanent ladders or handholds should be provided on the inside walls of basins and shall comply with latest OSHA regulations. Guard rails should be provided for any floors or walkways adjacent to open basins.

13. Residuals Disposal
    Methods of residuals disposal should be identified. Residuals disposal shall be done in accordance with local, state, and federal requirements (see Section 5.10).

14. Chemical Feed
    The installation of chlorine feed points in sedimentation basins is recommended to allow shock dosing for maintenance purposes.

5.2.5 Tube Settlers

Tube settler units, consisting of variously shaped tubes or plates that are installed in multiple layers and at an angle to the flow, may be used for sedimentation following flocculation. Effectiveness of the settling unit should be demonstrated by piloting. General criteria are:

1. Inlet and Outlet Considerations
   Design shall maintain velocities suitable for settling in the basin and to minimize short-circuiting.

2. Drainage
   Drain piping from the settler units must be sized to facilitate a quick flush of the settler units and to prevent flooding other portions of the plant.

3. Protection from Freezing
   A cover or enclosure should be provided to protect against weather and contamination.

4. Application Rate
   The recommended rate should be 1 to 3 gal/min/ft^2 of cross-sectional area (based on 24-inch-long 60 degree tubes or 39.5-inch-long 7.5 degree ration studies tubes) unless higher rates are successfully demonstrated through pilot plant or in-plant demonstration studies.

5. Flushing Lines
   Water and/or air flushing lines shall be provided to facilitate routine flushing of floc buildup in and/or above the tubes. Water lines in the basins must be properly protected against backflow or back siphonage.

6. Residuals Removal
   Mechanical residuals removal should be provided (see Section 5.10).

5.2.6 Solids Contact Unit

Units are generally acceptable for clarification where: water characteristics especially temperature does not fluctuate rapidly, flow rates are uniform, and operation is continuous. Before such units are considered as clarifiers, approval of MassDEP shall be obtained. Clarifiers should be designed for the maximum uniform rate and should be adjustable for changes in flow that are less than the design rate and for changes in water characteristics. A minimum of two units is required for surface water treatment.

1. Chemical Feed
   Chemicals shall be applied at such points and by such means as to insure satisfactory mixing of the chemicals with the water. Preliminary design documents submitted with the piloting report should contain diagrams of proposed application points of all chemicals.

2. Mixing
   A rapid mix device or chamber upstream of solids contact units may be required by MassDEP to assure proper mixing of the chemicals applied. Mixing devices shall:

   a. Provide good mixing of the raw water with previously formed residuals particles

   b. Prevent deposition of solids in the mixing zone

3. Flocculation Equipment:

   a. Shall be adjustable (speed and/or pitch)

   b. Must provide for coagulation in a separate chamber or baffled zone within the unit

   c. Should provide a flocculation and mixing period of no less than 20 minutes

4. Residuals Concentrators

   a. The equipment should be designed with either internal or external concentrators in order to obtain a concentrated residual with a minimum of wastewater.

   b. Large basins should have at least two sumps for collecting residuals with one sump located in the central flocculation zone for draining.

   c. See Section 5.10 for details on residuals.

5. Detention Time
   The detention time shall be established on the basis of the raw water characteristics and other local conditions that effect the operation of the unit. Based on design flow rates, the detention time within the mixing zone and settling zone should be between 2 and 4 hours. MassDEP may allow alternative detention times on the basis of successful pilot study results.

6. Suspended Slurry Concentrate
   Softening units should be designed so that continuous slurry concentrates of 1% or more by weight can be satisfactorily maintained.

7. Water Losses
   Units shall be provided with suitable controls for residuals withdrawal.

8. Weirs or Orifices
   The units should be equipped with either overflow weirs or orifices constructed so that water at the surface of the unit does not travel over 10 feet horizontally to the collection trough.

   a. Weirs shall be adjustable and at least equivalent in length to the perimeter of the tank.

b. Weir loading shall not exceed 10 gal/min/ft of weir length for units used for clarifiers.

c. Where orifices are used, the loading per foot of launder rates should be equivalent to weir loadings. Either shall produce uniform rising rates over the entire area of the tank.

9. Upflow Rates
The upflow rates should be 1.0 gal/min/ft^2 of area at the sludge separation line for units used for clarifiers. MassDEP may allow higher upflow rates on the basis of successful pilot study results.

10. Pulsating or Upflow Units
Pulsating or upflow settling units may be used for clarifying sedimentation of flocculated waters. The pilot study shall identify and justify this type of construction. These types of units shall contain all provisions outlined under the general requirements of solid contact units.

5.2.7 Dissolved Air Flotation

Dissolved air flotation (DAF) is a clarification process that is based on the transfer of particles to the surface of a liquid through attachment of bubbles to the particle surface. The particles are removed as floating solids by mechanical skimming. The piloting evaluation shall identify and justify this type of solids removal. Refer to Section 5.10 for details on residuals management.

1. DAF may be recommended when waters contain high levels of low-density particles such as algae.

2. The typical DAF process train consists of chemical and air injection, flocculation, flotation, and skimming.

3. A portion of the flotation tank effluent is recycled, pressurized, and saturated with air.

4. Surface loading rates ranging from 3 to 5 gal/min/ft^2 are recommended. Higher loading rates must be demonstrated through piloting.

5. Baffling is required at the tank influent to direct the incoming flow toward the tank surface while reducing its velocity to minimize disturbance of the floating residual layer.

5.2.8 Contact Adsorption Clarifier

Contact adsorption clarifiers combine coagulation, flocculation, and clarification processes into a single upflow adsorption clarifier. The clarifier uses contact flocculation/adsorption to remove turbidity. Refer to Section 5.10 for details on residuals management.

1. A media loading rate should be determined based on piloting data.

2. Media size and bed depth should be determined based on piloting results.

3. Effective media size is typically 4 to 6 mm and media depth is generally 4 feet.

5.3 Filtration

5.3.1 General Information

1. Acceptable Filters
   Acceptable filters shall include the following:

   a. Dual and mixed media

   b. Granular activated carbon

   c. Deep bed anthracite or coarse sand

   d. Diatomaceous earth

   e. Membranes

   f. Bag and Cartridge

2. Filtration Processes
   Many filtration processes should be considered and may include the following:

   a. Rapid rate gravity filters

   b. Direct filtration

   c. Diatomaceous earth filtration

   d. Slow sand filtration

   e. Pressure filters

   f. Suction and pressure membranes

   The application of any filtration process shall be supported by water quality data representing a reasonable period of time to characterize variations in water quality. Pilot studies may be required to demonstrate the applicability of a proposed filtration process.

3. Surface Water Treatment Rule

   To ensure compliance with the Surface Water Treatment Rule:

   a. Filtration facilities shall include a continuous turbidimeter with recorder to monitor the effluent turbidity from each individual filter and in the composite filter effluent line. Access should be made for taking regular grab samples. If continuous monitoring is impractical, routine monitoring of individual filters is recommended as a minimum.

b. New treatment facilities shall have the capability of filter-to-waste whenever a filter is put on-line, initially and following backwash. Existing treatment facilities shall be retrofitted with this capability if possible.

c. Filters removed from service for extended periods of time should be backwashed upon start-up and where possible, an increased dosage of disinfectant shall be applied to the effluent.

d. Additional credit for log removal inactivation of up to 0.5 logs may be considered for filtration facilities other than conventional facilities. Credit will be given for the completion and maintenance of an approved watershed control program that reduces the potential for source water contamination.

e. Filter media shall be regularly inspected for wear and replaced as necessary.

5.3.2 Rapid Rate Gravity Filters

1. Number of Filters

   If the water system is dependent upon the proposed facility to meet the average daily demand, at least two separate filtering units with bypasses to one another shall be provided. Where only two units are provided, each shall be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than two filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service.

2. Rate of Filtration

   Average filtration rates should not exceed 3 gal/min/ft^2 except that higher rates may be allowed through consideration of factors such as raw water quality control, monitoring for turbidity and other parameters, staffing, and other factors as required by MassDEP. In any case, the filter rate must be proposed and justified by the designing engineer to the satisfaction of MassDEP prior to the preparation of final plans and specifications.

3. Structural Details and Hydraulics

   The filter structure design shall include the following:

   a. Vertical walls within the filter

   b. No protrusion of the filter walls into the filter media

   c. Cover by superstructure

   d. Trapped effluent to prevent backflow of air to the bottom of the filter

e. Prevention of floor drainage to filter with a minimum 4-inch curb around the filters

f. Prevention of flooding by providing overflow

g. Washwater drain capacity to carry maximum flow

h. Walkways around filters cannot be less than 24 inches wide

i. Safety handrails or walls around filter areas adjacent to normal walkways

j. Construction to prevent cross connections and permeable common walls between potable and non-potable water

k. Accessibility by the operator to obtain samples from the effluent channels or sampling pumps

4 Washwater Troughs

The washwater trough design shall include the following:

a. The elevation of the bottom of the troughs shall be determined based upon the type of backwashing process i.e., air and water or water alone. In no instance shall the bottom of the trough interfere with the expansion of the media.

b. A level top edge

c. Spacing so that each trough serves the same number of square feet of filter area

d. Maximum horizontal travel of suspended particles to reach the trough not to exceed 4 feet

5. Filter Bottoms and Strainer Systems

The manifold-type collection system design shall:

a. Minimize loss of head in the manifold and laterals

b. Assure even distribution of washwater and even rate of filtrate collection over the entire area of the filter

c. Provide the ratio of the area of the final openings of the strainer systems to the area of the filter at about 0.003

d. Provide the total cross-sectional area of the laterals at approximately twice the total area of the final openings

e. Provide the cross-sectional area of the manifold at 1-1/2 to 2 times the total area of the laterals

Note: Departures from these standards may be acceptable for high rate filters and for proprietary bottoms.

7. Surface Wash Facilities

   Surface wash facilities are recommended and may be accomplished by a system of fixed nozzles or a revolving type apparatus. All devices shall be designed with:

   a. Provisions for operating water pressures of at least 45 psi for pressure filters and 20 psi for gravity filters

   b. A properly installed approved device to prevent back siphonage, if connected to the treated water system

   c. Rate of flow between 2.0 to 4.0 $gal/min/ft^2$ of filter area with fixed nozzle or 0.5 to 1.0 $gal/min/ft^2$ with revolving arms

7. Air Scouring

   Air scouring can be considered in place of surface wash providing it meets the following conditions:

   a. Air flow for air scouring the filter must be 2 to 5 standard $ft^3/min/ft^2$.

   b. Concurrent washwater rates must not exceed 8 $gal/min/ft^2$ unless a method of retaining the filter media is provided. The maximum rate should be determined based on the type of media used and the amount of time that is desirable for cleaning the media when using air and water in combination.

   c. If dual media is used, air scouring must be followed by a fluidization wash sufficient to restratify the media.

   d. Air must be protected against contamination from compressor or exhausts or other potential contaminants.

   e. No air wash piping shall be placed in the filter media unless approval of piping and backsiphonage valving is obtained from MassDEP.

   f. Underdrain and air manifold shall be designated to accommodate air and water backwash.

   g. Provisions of Section 5.3.2 shall be followed.

8. Appurtenances
   Every filter shall have:

   a. Provisions for sampling and observation of influent and effluent waters, where applicable

   b. A gauge indicating loss of head

   c. A raw water flow meter indicating flow rate. A modified rate controller that limits the rate of filtration to a maximum rate may be used. However, equipment that simply maintains a constant water level on the filters is not acceptable, unless the rate of flow into the filter is properly controlled. A pump or a flow meter in each filter effluent line may be used as the limiting device for the rate of filtration only after consultation with MassDEP.

d. A continuous turbidity monitoring recording device for surface water treatment plants

e. A 1 to 1-1/2 inch pressure hose and storage rack within the filter room for washing filter walls with hot water, if available

f. Wall sleeves providing access to the filter interior at several locations for sampling or pressure sensing

g. Provisions for draining the filter to waste when gravity drains are not installed (Appropriate measures for backflow prevention such as an air gap should be used.)

Note: Subsections b and c may not apply to automatic continuous backwash filters and shall be determined by MassDEP.

9. Backwash
Provisions shall be made for backwashing filters as follows:

a. A recommended rate of 10 to 20 gal/min/ft², dependent upon type of media and consistent with water temperature and specific gravity of the filter media. A rate of flow to provide for a 50% expansion of a granular activated carbon filter bed and up to 30% expansion for other medias is recommended.

b. Filtered water shall be provided at the required rate by washwater tanks, a washwater pump, clearwell, or a combination of these. Use of a high service main may be allowed but only with a pressure-regulating valve to prevent high pressure damage to the underdrain system and disruption of the media. Distribution system pressures shall not fall below 30 psi.

c. Washwater pumps in duplicate unless an alternate means of obtaining washwater is available

d. Sufficient storage of filtered water to backwash one filter at the maximum rate

e. A rate of flow controller or valving with totalizing capability as a minimum shall be provided on the main washwater line to obtain the desired rate of filter wash.

f. Rate of flow controls shall be designed to prevent rapid changes in backwash water flow.

Note: Subsections a, c, d, and e do not apply to automatic, continuous backwash filters.

10. Filter Media

Filter media shall be clean silica sand or other natural or synthetic media approved by MassDEP. Other media and media depths will be considered based on pilot test data, specifications, and operating data. Types of filter media include:

a. Anthracite - Clean crushed anthracite or a combination of anthracite and other media may be considered on the basis of pilot test data specific to the project and shall have:

   (1) Effective size of 0.6-1.6 mm depending on the intended use

   (2) Uniformity coefficient of not greater than 1.5

b. Sand - Sand shall have:

   (1) Effective size of 0.35 mm to 0.55 mm

   (2) Uniformity coefficient not greater than 1.65

b. Granular Activated Carbon - Use of granular activated carbon as a filter media, must be justified by the following criteria:

   (1) During piloting or design, various types of granular activated carbon shall be tested for optimum effectiveness and absorption capacities on the water(s) being treated. Contract specifications should specify AWWA standards recommendations for iodine testing to determine activated levels of granular activated carbon prior to installation.

   (2) Based on testing results, each bed of granular activated carbon should be tested annually, at a minimum, to determine adsorption capacity and filtering effectiveness.

   (3) Particle size, specific gravity and adsorptive capacities of granular activated carbon shall be based on site-specific needs. Piloting and design evaluation should take into account the nature of the water to be treated, particular treatment process used and pre-filtering treatment processes.

   (4) Effective size of granular activated carbon shall be from 0.35 mm to 1.30 mm.

   (5) Surface loading rates and bed depth should be based on piloting results.

   (6) Uniformity coefficient should not exceed 2.1 after filter backwash.

c. Gravel - When used as the supporting media, shall consist of hard, rounded particles and shall not include flat or elongated particles. The coarsest gravel shall be 2-1/2 inches in size when the gravel rests directly on the strainer system, and must extend above the top of the perforated laterals. Not less than four layers of gravel shall be provided in accordance with the following size and depth distribution when used with perforated laterals:

Size	**Depth**
2-1/2 to 1-1/2 inches	5-8 inches

1-1/2 to 3/4 inches	3-5 inches
3/4 to 1/2 inches	3-5 inches
1/2 to 3/16 inches	2-3 inches
3/16 to 3/32 inches	2-3 inches

Reduction of gravel depths may be considered upon justification to MassDEP when proprietary filter bottoms are specified.

d. Multi and Mixed Media
Filtration by other media, using types of multi media and mixed media as an innovative technology, will be considered based on pilot plant study data and operational experience in New England.

11. Miscellaneous

a. Roof drains shall not discharge into the filters, basins, or conduits within the water treatment facility.

b. It is recommended that granular activated carbon filters should have water jet carbon eductor hardware, including hoses for removal and replacement of media although manual replacement by the manufacturer will be accepted.

5.3.3 Pressure Filters

The use of these filters is not recommended for surface supplies and is generally not approved since their effectiveness is easily reduced and their operation difficult to monitor. However, they may be approved on a case-by-case basis as conditions warrant.

1. General

a. Minimum criteria relative to number, rate of filtration, structural details and hydraulics, filter media, etc., provided for rapid rate gravity filters also apply to pressure filters where appropriate

b. The specific media shall be approved by MassDEP.

2. Rate of Filtration

The rate should not exceed the rate used in the pilot study. In any case the filter rate must be proposed and justified by the designing engineer to the satisfaction of MassDEP prior to the preparation of final plans and specifications.

3. Details of Design

The pressure filters design shall include:

a. Pressure gauges on the inlet and outlet pipes of each filter

b. A direct read flow indicator meter on each filtering unit and intake piping

c. Piping and valving design shall be arranged to allow for filtration, backwashing, air scouring and drain downstream of the filter.

d. A minimum side wall shell height of 5 feet. A corresponding reduction in side wall height is acceptable where proprietary bottoms permit reduction of the gravel depth and chemical contact times are acceptable.

e. The top of the washwater collectors shall be at least 18 inches above the surface of the media to minimize media discharge.

f. The underdrain system shall efficiently collect the filtered water and uniformly distribute the backwash water at a rate recommended for that approved media and filter.

g. Readable backwash flow indicators and solenoid valve and operating controls

h. An air release valve on the highest point of each filter

i. Two accessible manholes of sufficient size to allow human access to facilitate inspections and repairs

j. Provisions should be made to observe and sample the wastewater during backwash.

k. Construction shall prevent cross-connection.

l. A pressure relief valve shall be installed for each filter and on the main effluent discharge line from the facility.

5.3.4 Diatomaceous Earth Filtration

The use of these filters may be considered on the basis of successful pilot test results.

1. Types of Filters
   Pressure or vacuum diatomaceous earth filtration units will be considered for approval. However, the vacuum type is preferred for its ability to accommodate a design which permits observation of the filter surfaces for determining the following: proper cleaning, damage to a filter element, and adequate coating over the entire filter area.

2. Number of Filters
   If the water system is dependent on the proposed facility to meet the average daily demand, at least two units shall be provided. Where only two units are provided, each shall be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than two filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service.

3. Precoat

a. A uniform precoat shall be applied hydraulically to each septum by introducing slurry to the tank influent line and by employing a filter-to-waste or recirculation system.

b. The recommended quantity of precoat is 1 kg/m^2 (0.2 lb/ft^2) of filter area, and the minimum thickness of the precoat filter cake is 3 mm to 5 mm (1/8 to 1/5 inch).

4. Body Feed

A body feed system by use of a slurry tank, demixer and hopper shall be provided to apply additional amounts of diatomaceous earth slurry during the filter run to avoid short filter runs or excessive head losses.

a. Quantity - Rate of body feed is dependent upon raw water quality and characteristics and must be determined in the pilot plant study.

b. Operation and maintenance can be simplified by providing accessibility to the feed system and slurry lines with provisions for flushing.

c. Continuous mixing of the body feed slurry is required.

d. Coagulant to coat body feed to improve removal rates for viruses, bacteria and turbidity is required.

5. Filtration

a. Rate of Filtration
The recommended nominal filtration rate is 1.0 gal/min/ft^2 of filter area with a recommended maximum of 1.5 gal/ min/ft^2. Alternative rates may be accepted based on results from the pilot plant study.

b. Head Loss
The head loss shall not exceed 30 psi for pressure diatomaceous earth filters or a vacuum of 15 inches of mercury for a vacuum system.

c. Recirculation
A recirculation or holding pump shall be used to maintain differential pressure across the filter when the unit is not in operation in order to prevent the filter cake from dropping off the filter elements. A minimum recirculation rate of 0.1 gal/min/ft^2 of filter area shall be provided.

d. Septum or Filter Element
The filter elements shall be structurally capable of withstanding maximum pressure and velocity variations during filtration and backwash cycles, and shall be spaced such that not less than one inch is provided between elements or between any element and a wall.

e. Inlet Design
The filter influent shall be designed to prevent scouring of diatomaceous earth from the filter element.

6. Backwash

   Two air compressors, one as backup, shall be provided to thoroughly remove and dispose of spent filter cake during periods of backwash.

7. Appurtenances

   The following shall be provided for every filter:

   a. Sampling taps for raw and filtered water

   b. Loss of head or differential pressure oil filled gauges

   c. Rate-of-flow indicator, preferably with totalizer

   d. A manual and automatic controlled throttling valve to control flows

   e. Body feed, recirculation, and any other pumps required to insure the operation of the treatment system

5.3.5 Slow Sand Filtration

The use of this filtration technology shall require a pilot study to demonstrate the adequacy and suitability of this method of filtration for the raw water supply to be treated, unless waived by MassDEP.

1. Number of Filters

   At least two units shall be provided. Where only two units are provided, each shall be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than two filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service.

2. Structural Details and Hydraulics

   Slow rate gravity filters shall have:

   a. A cover

   b. Headroom to permit normal movement by operating personnel for scraping and sand removal operations

   c. Adequate manholes, ladders and access ports for handling of sand

   d. Valving and piping to allow for filtration to waste

   e. An overflow to an approved location (installed at the maximum filter water level elevation)

3. Rates of Filtration

   The permissible rates of filtration shall be determined by the quality of the raw water and shall be on the basis of pilot plant study data derived from the water to be treated. The nominal rate may be 45 to 150 gal/day/ft^2 of sand area, with somewhat higher rates accepted based on piloting results.

4. Underdrains

   Each filter unit shall be equipped with a main drain and an adequate number of lateral underdrains to collect the filtered water. The underdrains shall be spaced so that the maximum velocity of the water in the lateral underdrain will not exceed 0.75 ft/sec. The maximum spacing of the laterals shall not exceed 12 feet.

5. Filtering Material

   a. Filter sand shall be placed on graded gravel layers for a minimum depth of 30 inches.

   b. The effective size shall be between 0.15 mm and 0.35 mm.

   c. The uniformity coefficient shall not exceed 2.5.

   d. The sand shall be clean and free from foreign matter.

6. Filter Gravel

   The supporting gravel shall conform to the size and depth distribution provided for rapid rate gravity filters (see Section 5.3.2).

7. Depth of Water on Filter Beds

   Design shall provide a depth of at least 3 feet of water over the sand. Influent water shall be distributed by use of weirs or inlets designed to prevent scouring of the sand surface during filling.

8. Operating Requirements

   Maintenance of a slow sand filter involves two periodic tasks:

   a. Removal of the top 2 to 3 cm (0.8 to 1.2 inches) of the surface of the sand bed when the headloss exceeds 1 to 1.5 m
   b. Replacement of the sand when repeated scrapings have reduced the depth of the sand to approximately one-half of its design depth

5.3.6 Direct Filtration

Direct filtration refers to the filtration of surface water without prior settling. The nature of the treatment process will depend upon the raw water quality. A full scale direct filtration plant shall not be constructed without prior pilot studies that are acceptable to MassDEP. In-plant demonstration studies may be appropriate where conventional treatment plants are converted to direct filtration. Where direct filtration is proposed, an engineering report shall be submitted prior to conducting pilot plant or in-plant demonstration studies.

Prior to the initiation of design plans and specifications, a final report including the engineer's design recommendations shall be submitted to MassDEP.

1. Pretreatment: Rapid Mix and Flocculation
   The final rapid mix and flocculation basin design should be based on the pilot plant or in-plant demonstration studies augmented with applicable portions of Sections 5.2.2 and 5.2.3.

2. Filtration

   a. The final filter design should be based on the pilot plant or in-plant demonstration studies augmented by applicable portions of Section 5.3.

   b. Surface wash shall be provided for the filters in accordance with Sections 5.3.2.6 and 7.

3. Control and Operation

   a. A continuous recording turbidimeter should be installed on each filter effluent line and on the combined filter effluent line.

   b. Additional continuous monitoring equipment may be required by MassDEP.

   c. Provisions of Section 5.3 also apply.

4. Siting Requirements

   The plant design should allow for the installation of conventional sedimentation basins when necessary.

5.3.7 Ultrafiltration (UF) And Microfiltration (MF)

Membrane processes are water conditioning processes by which dissolved minerals, or ions, are removed from water by the use of semi-permeable membranes. Membrane processes can be used to remove excess dissolved solids, a variety of organic contaminants, and, to a lesser extent, radionuclides from drinking water. Membrane processes can be used specifically for the removal of particulate material, including microorganisms such as protozoa (*Giardia* and *Cryptosporidium*), bacteria, and viruses. UF and MF are membrane processes which are considered filtration processes. In applications where the removal of dissolved minerals, total organic carbon (TOC), or trihalomethane (THM) precursors is not critical, UF and MF technology may be appropriate. These membrane processes can effectively remove from solution species such as larger organics, colloids, and microorganisms including viruses, bacteria, and cysts.

The use of this filtration technology shall require a pilot study to demonstrate the adequacy and suitability of this method of filtration for the raw water supply to be treated. The pilot study must take into consideration the quantity and quality of the raw water, the pre-treatment and post-treatment processes, corrosiveness of the finished water, and concentrate disposal.

Materials used in construction of UF or MF treatment processes shall be in conformance with ANSI/NSF Standard 61 (Drinking Water System Components – Health Effects – National Sanitation Foundation).

Some factors which should be considered in the design and operation of membrane filtration systems include:

1. Raw Water Source

   One of the most important aspects of membrane treatment plant selection and design is the source and character of the proposed raw water. The main water quality parameters that affect membrane production are turbidity, total organic carbon (TOC), and algae content. Membrane processes can be used to treat turbid waters but may result in higher operation and maintenance costs and possibly more frequent replacement of some membrane types.

2. Pre-Treatment

   Chlorine and its by-products have often proven to be a major cause of membrane failures. System designers must know the properties of the specific membranes to be used in the system to prevent this type of problem. Pre-treatment should include disinfection.

   For applications involving removal of various organics, disinfection by-product precursors, and SOCs, pre-treatment shall include the addition of activated carbon or coagulation, or both. Alum coagulation shall not be used as pre-treatment for UF because the alum will readily foul the membrane.

3. Design Criteria

   a. At least two UF or MF units shall be provided, with each unit capable of meeting the plant's design capacity. When more than two units are provided, the units shall be capable of meeting the plant's design capacity with the largest unit removed from service.

   b. A maximum thirty-six month membrane life should be assumed until satisfactory on-site data is generated.

   c. The design shall include the ability to measure plant flow rate of permeate and concentrate water.

   d. All units shall be equipped with a feed water and concentrate pressure gauge. The units should also be equipped with a permeate water pressure gauge.

   e. Taps for sampling feed (raw) water, permeate, concentrate, and finished water shall be provided.

   f. A 90% recovery is recommended.

g. On-line instrumentation for hydraulic and water quality characteristics should be provided for membrane feed water, permeate, and concentrate.

h. On-line instrumentation should be provided to measure flow, pH, temperature, and conductivity every four hours.

i. Automatic controls should be provided to shut down the system during high effluent turbidities, high pressure differential, or failure of the membrane integrity.

4. Post-Treatment

   For applications in which UF and MF processes are used to directly produce drinking water, post-treatment may include removal of toxic gases, improvement of taste and odor, and protection of the distribution system from corrosion and bacteria growth where necessary.

   For pre-treatment applications of UF and MF for reverse osmosis (RO), the product water from the UF or MF process may be fed directly to the RO system.

5. Membrane Cleaning

   UF and MF systems should be cleaned periodically to maintain flux levels.

   Detailed information concerning the manufacturer's cleaning requirements and types of cleaning chemicals should be submitted to MassDEP as part of the permit application. Proper disposal of cleaning chemicals is required and must comply with the latest state, local and federal regulations. Chemicals that may come in contact with the water or affect the quality of the water shall be certified to be in conformance with ANSI/NSF Standard 60 (Drinking Water Treatment Chemicals – Health Effects) or meet the food grade standards of the United States Pharmacopeia.

   In addition to routine cleaning, regular flushing of all membrane based systems is recommended.

5.3.8 Reverse Osmosis (RO) Membranes

Reverse osmosis is a pressure-driven process that retains virtually all ions and passes water. The pressure applied exceeds the osmotic pressure of the salt solution against a semi-permeable membrane, thereby forcing pure water through the membrane and leaving salts behind. RO units may utilize either spiral wound or hollow fiber membranes. RO units are very effective for seawater desalting, brackish water desalting, and fresh water treatment.

The RO process should not be used to treat waters with a total dissolved solids concentration exceeding 12,000 mg/L for low pressure (400 psi) membranes or 30,000 mg/L for high pressure (1,000 psi) membranes without justification. Detailed information outlining the required feed water quality and anticipated performance capabilities of the RO process shall be submitted with the permit application.

Some additional factors which should be considered in design and operation of RO units include the following:

1. Pre-Treatment

   Pre-treatment systems should be capable of producing feed water of a quality recommended by the manufacturer of the RO unit. Detailed information, including the manufacturer's feed water requirements, proposed pre-treatment equipment, and evidence that the proposed pre-treatment system is capable of producing the desired feed water quality, shall be included in the permit application. Generally, cartridge filtration immediately prior to the membrane is recommended.

   a. Pre-treatment for groundwaters should include acid and antiscalants to inhibit the formation of scale precipitates.

   b. Pre-treatment for surface waters should include disinfection for microbiological contaminants and some form of coagulation-flocculation and filtration for removal of suspended and colloidal matter. Ultrafiltration (UF) and microfiltration (MF) processes may be used as pre-treatment to extend membrane life.

   c. Pre-treatment of the feed water shall be provided to remove suspended matter or iron and manganese if the feed water contains 5 NTU or more turbidity or 0.3 mg/L or more of iron and manganese. Adjustment of the feed water pH to 5.5 is recommended when cellulose acetate (spiral wound) modules are used. Softening or pH adjustment is satisfactory pre-treatment for hollow fiber modules.

   d. Where the feed water pH is altered, stabilization of the finished water is mandatory. Stabilization is optional in other cases.

2. Design Criteria

   a. For community water systems, two RO units should be provided with each unit capable of meeting the system's design capacity. For non-community water systems, only one unit is required, provided it is equipped with appropriate lock-out to insure that all water consumed has been properly treated.

   b. Appurtenant equipment which should be considered in the design of the RO system should include the following:

      (1) A polishing membrane filter (less than or equal to eight microns for hollow fiber modules, or less than or equal to twenty-five microns for spiral wound modules) should be provided before the RO unit. Pressure gauges shall be provided on the upstream and downstream side of the filter. The filter shall be located to facilitate changes of the filtering membrane.

      (2) All units shall have feed water and permeate pressure gauges and have the capability to measure flow rates of permeate and concentrate water.

      (3) Taps for sampling permeate, concentrate, and blended (if practiced) flows should be provided.

(4) A conductivity meter shall be provided at each installation. A continuous conductivity meter, if installed, shall be constructed so that it may be disconnected from the piping system for calibration with standard solutions.

(5) An in-line turbidity meter should be provided on each stage.

(6) A maximum thirty-six month membrane life should be assumed until satisfactory on-site data is generated.

(7) An automatic high temperature alarm or cut-off switch shall be provided if the feed water is heated. The maximum temperature setting is generally between 80°-90° F depending on the membrane used.

(8) All units should be equipped with alarms or automatic controls to shut down the system during high effluent turbidities, high pressure differential or membrane failure (low pressure differential).

(9) Cleaning in place is usually accomplished at lower pressures but at two to three times the normal flow velocity on the concentrate side. Chelating agents as well as citric acid are acceptable provided the unit is adequately flushed following cleaning.

3. Post-Treatment

   Treated effluents from the RO process are usually low in pH and solids, high in carbon dioxide, and normally corrosive. Detailed information shall be submitted with the permit application concerning the anticipated corrosiveness of the product water and the methods proposed for stabilizing this water.

   Disinfection of the treated water is not required, unless otherwise determined by MassDEP.

4. Residuals

   For proper residuals management see Section 5.10.

5.3.9 Bag and Cartridge Filtration

Bag and cartridge filtration technologies are usually designed to meet low flow requirements typical of small non-community water supplies. Bag and cartridge filters can effectively remove particles from water in the size range of *Giardia cyst* (5-10 microns) and *Cryptosporidium* (2-5 microns). For *Cryptosporidium* removal the following sequence is recommended: a 10 micron (nominal) rated preliminary filter, a 5 micron (nominal) intermediate filter, and a 1 micron (absolute) final filter.

Bag and cartridge filters must be discarded once the particular loading capacity of the filters is expended. The life expectancy of a filter is dependent on many factors, including the quality and volume of water being treated and the type of cartridge. The manufacturer's recommended guidelines for bag and cartridge filters should be closely followed. Bag and cartridge filters are usually pressure type filters consisting of a membrane, fabric or string medium with particle size removal, ranging from 0.2 microns up to 10 microns.

Some additional factors to be considered in the design and operation of bag and cartridge filters include the following:

1. Materials

   The materials in contact with the water shall not impart undesirable taste, odor, color and/or toxic materials into the water as a result of the presence of toxic constituents in materials of construction.

   System components such as housing, cartridges, gaskets, and O-rings should be certified for performance with ANSI/NSF Standard 61. The filter housing shall be constructed to withstand a hydrostatic pressure of 125 psi.

2. Design

   a. The source water or pre-treated water should have a turbidity level of less than 5 NTU.

   b. Flow rates should be maintained at less than 1 gal/min/ft^2 of filter area, preferably 0.5 gal/min/ft^2, to minimize pressure loss and increase efficiency. The flow rate through the bag and cartridge filter must not exceed 20 gpm, unless documentation exists to prove the cartridge filters will meet the requirements for removal of particulates at high flow rates. An automatic fix flow rate control shall be provided as an integral part of the unit to prevent an influent flow rate in excess of the filtering capabilities at any time during its effective life. A totalizing meter should be provided to record daily flow.

   c. When various types of bag or filter cartridges or elements with different purposes and performances are available from the manufacturer, they shall bear differentiating identifications that are easily identified and clearly visible. Such identification shall be explained on the package containing the element or cartridge.

   d. Waste connections or outlets, if provided, should be through an air gap of not less than 1 inch. Special attention must be given to prevent cross connection between untreated and treated water.

   e. The dispenser spout, faucet, or outlet for treated water shall be designed, constructed and located such that when the unit is installed in conformance with the manufacturer's instructions, it is directed downward and readily accessible for use.

   f. It is recommended that chlorine or another disinfectant be added at the head of the treatment process to reduce or eliminate the growth of algae, bacteria, etc., on the filters. The impact on disinfection by-product formation should be considered. Disinfection of the filtered water may be required after filtration (see Section 5.4.1.1).

g. A filter-to-waste component is required for any pre-treatment pressure sand filters. At the beginning of each filter cycle and/or after every backwash a set amount of water shall be discharged to waste before flow begins into the bag filter.

h. A sampling tap should be provided ahead of any treatment so that a source water sample can be collected.

i. A bag or cartridge filter should be constructed or equipped to preclude operation beyond the effective life of the bag or cartridge filter. This may be accomplished by one of the following means:

   (1) The unit becomes inoperable when the effective life of the bag filter or cartridge is reached, or

   (2) The unit is provided with an easily visible and readily interpretable means of guiding the operator in determining the effective life of the bag or cartridge.

j. Frequent start and stop operations of the bag and cartridge filter should be avoided. One of the following operations is recommended in order to avoid frequent start / stop cycles:

   (1) Slow opening and closing of valve ahead of the filter to reduce flow surges,

   (2) Reduce the flow through the cartridge filter to as low as possible to lengthen filter run times, or

   (3) Install a recirculating pump that pumps treated water back to the head of the cartridge filter. Care must be taken to make sure there is no cross connection between the finished water and raw water.

k. A pressure relief valve should be incorporated into the bag and cartridge filter housing.

l. Pressure gauges must be provided before and after each bag and cartridge filter to properly monitor system pressure loss.

m. An automatic air release valve should be installed on top of the filter housing.

n. A minimum of two bags or cartridge housings should be provided for water treatment systems that must provide water continuously.

3. Installation

All units shall be readily accessible for maintenance, service inspection, and cleaning. The cartridges filter elements and other replacements shall be readily removable and easily replaced.

Spare cartridges, filter elements, and other replacement components are to be provided to allow prompt replacement and / or repair by a qualified person properly instructed in the operation and maintenance of the equipment.

4. Operation

   a. Complete automation of the water treatment plant is not required. Automation of the treatment plant should be incorporated into the ability of the water system to monitor the finished water quality. A properly certified operator shall be available to run the treatment plant.

   b. A plan of action should be in place should the water quality parameters fail to meet EPA standards or the guidelines of MassDEP.

   c. The filter and the back wash rates shall be monitored so that the prefilters are being used optimally. The bag and cartridge filter must be replaced when a pressure difference of 30 psi or other pressure difference recommended by the manufacturer is observed.

   d. Additional observation of filter runs is required near the end of filter runs.

   e. Maintenance (O-ring replacement) shall be performed in accordance with the manufacturer recommendations.

   f. The following parameters should be monitored:

      (1) Instantaneous flow rate

      (2) Total flow rate

      (3) Operational pressure

      (4) Pressure differential

      (5) Turbidity

5.3.10 Treated Water Storage - Clearwell

The water supply works (including all treatment facilities and sources of supply) should be capable of delivering, in connection with the storage on the distribution system, the maximum daily consumption plus the required fire flow. Accordingly, required clearwell storage shall be sized taking into account the present storage needs to meet the aforementioned requirement as recommended by AWWA and the Insurance Services Organization (ISO).

The following shall apply for sizing and operation:

1. The operator shall be able to safely shut down the treatment train and/or facility during periods of mechanical failure and/or during periods of allowed unoperated supervision.

2. The clearwell shall allow the system to have continuity of flow through the filters for each treatment train at uniform rates during all conditions of system demand at or below the approved filtration rate.

3. The clearwell shall be able to guarantee continuity of service during adverse raw water conditions without bypassing the system.

4. Baffling is recommended to increase plug flow zone in the basin and minimize short-circuiting to meet CT requirements of the Surface Water Treatment Rule.

5. Overflows may be discharged directly back to surface waters and shall be equipped with the appropriate level of instrumentation. Overflow elevations shall be designed to prevent flooding of the water treatment facility.

6. Design shall conform to the requirements in Chapter 8.

5.4 DISINFECTION

5.4.1 General Information

1. Applicability

Disinfection requirements of the Surface Water Treatment Rules, the Ground Water Rule (GWR) and MassDEP's disinfection regulations, guidelines and policies must be met when applicable. All disinfection byproduct MCLs and MRDLs shall not be exceeded while meeting disinfection requirements. Disinfection is an important barrier to contamination and is recommended for all water supplies.

Disinfection may be permanent, temporary, or optional.

a. Permanent Disinfection

Permanent disinfection shall be required:

(1) At all terminal surface water sources

(2) At ground water sources determined by MassDEP to be under the influence of surface water

(3) At ground water sources required to disinfect in compliance with the Ground Water Rule

(4) At ground water sources determined by MassDEP to be in compliance with the Ground Water Rule but of questionable sanitary or bacterial quality. This determination can be made at any time including during a pump test.

(5) After exposed treatment processes on ground water sources; for example, exposed filtration and exposed aeration and also after exposed chemical treatment when required by MassDEP

(6) After enclosed treatment processes on ground water sources where MassDEP determines that there are significant pathogens present in the treated water based

on routine and additional monitoring described below in 5.4.1.1.f. These systems shall be classified as being of questionable sanitary or bacterial quality and shall meet MassDEP disinfection guidelines for water systems. Examples of enclosed treatment include pressure filters and enclosed aeration (e.g. packed tower, venturi, pressure, diffused bubble, etc). MassDEP considers the following as indicative of significant pathogen presence:

(a) Two or more coliform bacteria MCL exceedences in a twelve month period which can be traced to treated water coliform bacteria detects

(b) Confirmed presence of coliform bacteria immediately after treatment two or more times within a twelve-month period

(c) Confirmed presence of coliform bacteria in a system immediately after new treatment during pilot testing

(d) Any other related circumstance as identified by MassDEP

(7) For any other treatment as determined by MassDEP

b. Temporary Disinfection

MassDEP may require any system to install disinfection on a temporary basis to address an immediate short-term bacteria problem at a ground water source or immediately after treatment. New groundwater sources must demonstrate that they have the necessary funding and infrastructure to install and monitor disinfection treatment if required.

Temporary disinfection shall be required after cleaning of a component of an enclosed treatment system such as a pressure filter or clearwell and in any other circumstance as required by MassDEP.

c. Optional Disinfection

Any water system wishing to install disinfection when not required to do so must apply to MassDEP for approval. Care shall be taken to insure that no MCLs or MRDLs are exceeded and that required monitoring and reporting is satisfied.

d. Discontinuing Disinfection

An existing ground water system not subject to the guidelines in 5.4.1.1.a. with only disinfection for treatment or with disinfection in an enclosed treatment system that wishes to discontinue disinfection shall submit a written request to MassDEP. This request shall be in report format and contain the following minimum information:

(1) Raw water coliform bacteria results for at least two years of continuous monitoring in accordance with their MassDEP approved sampling schedule. Additionally, those systems on MassDEP approved quarterly monitoring for raw water bacteria must sample monthly for one year and submit results to MassDEP if wishing to obtain approval to discontinue disinfection.

(2) Date well placed on line

(3) The reason(s) why the system installed disinfection, e.g. whether the system was required by MassDEP to disinfect in the past and if not required, then why is it being done.

e. Distribution System Disinfection

MassDEP may require permanent or temporary disinfection for coliform bacteria detects occurring as a result of distribution system problems such as biofilm and cross-connections.

f. Required pathogen monitoring for ground water sources with enclosed treatment but no disinfection

MassDEP will use these monitoring criteria to determine if there are significant pathogen presences in raw water or immediately after treatment.

(1) Monitoring
Triggered monitoring for the Ground Water Rule fecal indicator shall be required at the raw water source(s). Monitoring for total coliform and/or Ground Water Rule fecal indicators shall be required immediately after enclosed filtration or enclosed aeration. Monitoring immediately after other enclosed treatment such as chemical addition shall be at the discretion of MassDEP. Frequency of monitoring after treatment shall be as determined by MassDEP. Where there are no significant presences of pathogens, disinfection is optional (see Section 5.4.1.1.a. (6)).

(2) Additional Monitoring
MassDEP shall require additional coliform bacteria monitoring for the following:

(a) For one or more MCL violations over a twelve-month period in either source water or treated water

(b) For treated water after installation of new treatment

(c) In a new ground water source which has experienced coliform detects during a pump test

(d) In any other related circumstance as required by MassDEP

(3) Frequency shall be as determined by MassDEP.

2. Contact Time (CT)

Satisfactory disinfection contact time is required at facilities treating surface water or ground water under the direct influence of surface water:

a. To demonstrate that a water supply maintains disinfection conditions that inactivate *Cryptosporidium*, *Giardia lamblia* and viruses, the system must monitor and record the disinfectant(s) used, disinfectant residual(s), disinfectant contact time(s), pH, and water temperature. This data is used to determine if minimum total inactivation requirements of the Surface Water Treatment Rules are being met.

b. The CT value(s) for a system's disinfection conditions are calculated during peak hourly flow once each day that the system is delivering water to its customers. CTs during all flow conditions shall be sufficient to achieve the amount of inactivation of *Cryptosporidium*, *Giardia* and viruses required by 310 CMR 22.20A for all water that is delivered to its customers unless otherwise determined by MassDEP.

c. Residual disinfectant concentration is the concentration of the disinfectant (in mg/L) at a point before or at the first customer.

d. Contact time in pipelines must be calculated based on plug flow by dividing the internal volume of the pipeline by the peak hourly flow rate through that pipeline.

e. Contact time within mixing basins, settling basins, storage reservoirs, and any other tankage must be determined by tracer studies or an equivalent method, as determined by MassDEP. The contact time determined from tracer studies to be used for calculating CT is T_{10}. T_{10} is the detention time corresponding to the time for which 90% of the water has been in contact with the residual concentration. Guidance for determining contact times for basins is provided in *Appendix C* of the *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*, the latest relevant EPA Rules and guidance manuals, and MassDEP regulations 310 CMR 22.20A.

f. Contact Time Tracer Study Protocol- (see Section 5.1.6.2)

g. For systems that disinfect with ultraviolet light, refer to tables listing UV dosages necessary to meet inactivation requirements for *Cryptosporidium*, *Giardia* and viruses published in EPA's LT2ESWTR and guidance manual. Log credit is based on validated UV dose in relation to UV dose table, reactor validation testing required to establish UV dose and associated operating conditions. See specific criteria in 141.720(d) of the LT2ESWTR and guidance manual (see Section 5.4.6).

3. Point of Application

For systems that disinfect with chlorine, provisions should be made for applying chlorine to the raw water, settled water, filtered water, and water entering the distribution system.

4. Demonstration of Maintaining a Residual

a. Facilities disinfecting surface water or ground water under the direct influence of surface water (except those using ultraviolet light):

(1) A minimum disinfectant residual of 0.2 mg/L entering the distribution system must be maintained.

(2) The disinfectant residual cannot be less than 0.2 mg/L for more than four hours.

(3) A detectable residual must be maintained throughout the distribution system.

Alternatively, this requirement can be met through heterotrophic plate count (HPC) sampling. Note that actual measurement of the residual is still required under the Stage 1 Disinfectant/Disinfection Byproduct Rule to demonstrate compliance with the MRDL.

b. Facilities chlorinating groundwater of questionable sanitary quality not triggered into disinfection by the Ground Water Rule:

(1) A minimum free chlorine residual of 0.2 mg/L after a 10-minute contact time shall be maintained entering the distribution system**.** Contact time in this application is determined by taking a sample of water at a tap immediately after the point of chlorine addition, letting the sample stand for ten minutes then adding the proper reagents and immediately measuring the free chlorine residual using an approved analyzer. However, if a water system can meet the 10-minute contact time and required free chlorine residual through storage at the treatment plant then the previous methodology would not apply.

This minimum requirement may be significantly enhanced when determined by MassDEP to be necessary (e.g. a conventional water filtration plant treating ground water utilizing many different unit processes to remove iron, manganese, color etc.).

(2) In those cases where a chloramine residual is desired in the distribution system, a minimum free residual of 0.2 mg/L must be maintained for at least ten minutes prior to the addition of ammonia.

(3) Higher disinfectant residuals may be required depending upon pH, temperature and other characteristics of water.

(4) Maintenance of a detectable chlorine or chloramine residual in all parts of the distribution system is desirable.

c. Facilities disinfecting with UV see Section 5.4.6.1.

d. Facilities disinfecting in compliance with the Ground Water Rule refer to the rule specifics for maintaining a residual in the distribution system and/or entry point to the distribution system

5. Disinfection Methods

Approved Methods:

a. Chlorination

b. Chloramination

c. Ozonation

d. Chlorine dioxide

e. Ultraviolet light

f. Other methods approved by MassDEP

5.4.2 Chlorination

Chlorination may be accomplished with calcium or sodium hypochlorite or chlorine gas solution.

1. Chlorination Equipment

   a. Type
   Solution-feed-gas chlorinators or hypochlorite feeders of the positive displacement type must be provided (see Chapter 6).

   b. Capacity
   The chlorinator capacity shall be such that a free chlorine residual of at least 2 mg/L can be attained in the water after contact time of at least 30 minutes when maximum flow rates coincide with anticipated maximum chlorine demands. The equipment shall be designed to operate accurately over the desired feeding range.

   c. Standby Equipment
   Where chlorination is required for protection of the supply, complete standby equipment of sufficient capacity shall be available to replace the largest unit during shutdown. Emergency or standby power shall also be available.

   d. Automatic Proportioning
   Automatic proportioning chlorinators will be required where the rate of flow or chlorine demand is not reasonably constant.

   e. Changeover Equipment
   Whenever gas chlorine is used, automatic changeover equipment to switch from one cylinder or bank of cylinders to another cylinder or bank of cylinders must be provided to ensure that unchlorinated water is not allowed into the distribution system. Spare parts shall be made available to replace parts subject to wear and breakage.

   f. Alarms-visual and audio alarms must be provided for detection of chlorine gas leaks or overfeed

   g. See Section 6.4 for chlorine gas installation.

2. Testing Equipment

   Chlorine residual test equipment recognized in the latest edition of *Standards Methods for the Examination of Water and Wastewater* shall be provided and should be capable of measuring residuals to the nearest 0.1 milligrams per liter. MassDEP requires that all systems, as a minimum, use an instrument employing the DPD colorimetric method with a digital readout and a self-contained light source unless otherwise approved by MassDEP.

3. Chlorination Piping

   The piping system for the injection of chlorine into the water should be of suitable material and should be as direct as possible. An installation whereby chlorine may be applied to the water from each unit independently is preferred. However, under special conditions, the chlorinators may be manifolded together and a single line run to the point of injection. If only one line is run from the chlorinators to the point of injection, an extra corporation cock should be installed for emergency use.

4. Housing

   Adequate housing shall be provided for the chlorination equipment and for storing the chlorine (see Chapter 6).

5.4.3 Chloramination

1. General Information

   a. Chloramines are useful for controlling trihalomethane formation, maintaining a disinfectant residual in water distribution systems, and other related applications. Chloramines tend to remain active for longer periods and at greater distances from the plant than free chlorine. Chloramine concentrations should be maintained higher than free chlorine to avoid nitrifying bacterial activity.

   b. Patients on kidney dialysis machines may be particularly affected by chloramines especially monochloramine. Public water systems using chloramines as the terminal disinfectant shall advise area hospitals, health clinics and the local board(s) of health annually of the presence of monochloramine in the tap water. Notification shall be made to the parties noted above in public notice format or as approved by MassDEP.

   c. Chloramines in water are considerably more toxic to fish and other aquatic organisms than free chlorine. Consideration must therefore be given to potential for leaks to contaminate and damage natural water course ecosystems. Public water systems should inform pet stores with fish tanks and aquariums.

   d. Chloramines are a much weaker oxidant than free chlorine, chlorine dioxide, or ozone and are not recommended as a primary disinfectant. When using chloramination as a secondary disinfectant, unless specifically approved otherwise by MassDEP, chlorine shall be added and thoroughly mixed in the water prior to the addition of ammonia.

      (1) Where chloramination is required for protection of the supply, complete standby equipment of sufficient capacity shall be available to replace the largest unit during shutdown. Emergency or standby power shall also be available.

      (2) Visual and audio alarms shall be provided for detection of chlorine and ammonia gas leaks.

(3) Alarming and continuous analyzers are recommended to prevent overfeeding

e. Chloramination Impacts

(1) When chloramines are used in water treatment as a residual disinfectant, it can change the chemical properties of the water which subsequently can impact lead and copper corrosion. Certain conditions related to pH, alkalinity, and dissolved inorganic carbonate levels in the water can cause lead to dissolve from pipe material.

(2) Chloramination, if not properly optimized, can result in nitrification (conversion of ammonia into nitrite and then nitrate) in the presence of bacteria. Nitrification can lower the pH of the water, which can increase corrosion of lead and copper. The following are recommended:

(a) Water systems planning to use chloramination must review US EPA Simultaneous Compliance Guidance Manual.
(b) Water systems using chloramination must perform an optimal corrosion control treatment study prior to introducing chloramines into the distribution system.
(c) Water systems using chloramination may need to add chemicals to the finished water to form a protective coating on the pipes, such as an orthophosphate corrosion inhibitor.
(d) Water systems using chloramination shall optimize the chloramination process to minimize the possibility of nitrification that can reduce pH and increase corrosion.

f. Where chloramination is required for protection of the supply, complete standby equipment of sufficient capacity shall be available to replace the largest unit during shutdown. Emergency or standby power shall also be available.

g. Visual and audio alarms shall be provided for detection of chlorine and ammonia gas leaks.

h. Alarming and continuous analyzers are recommended to prevent overfeeding.

2. Forms of Ammonia

a. Ammonia for chloramine formation may be added to water either as a water solution of ammonium sulfate or, as aqua ammonia, (ammonia gas in water solution) or as anhydrous ammonia (purified 100% ammonia in liquid or gaseous form). Special provisions required for each form of ammonia are listed below:

(1) Ammonium sulfate

A water solution is made by addition of ammonium sulfate solid to water with agitation.

(a) The tank and dosing equipment contact surfaces should be made of corrosion resistant non-metallic materials.

(b) Provision should be made for removal of the agitator after dissolving the solid.

(c) The tank should be fitted with a lid and vented outdoors.

(d) Injection of the solution should take place in the center of treated water flow at a location where there is high velocity movement.

(2) Aqua ammonia (ammonium hydroxide)

Aqua ammonia feed pumps and storage shall be enclosed and separated from other operating areas. The aqua ammonia room shall be equipped as in Section 6.4 with the following changes:

(a) A corrosion resistant, closed, unpressurized tank shall be used for bulk storage. The tanks shall be vented through an inert liquid trap to a high point outside and an incompatible connector or lockout provisions shall be made to prevent accidental addition of other chemicals to the storage tank.

(b) The storage tank shall be fitted either with cooling/refrigeration and/or with provisions to dilute and mix the contents with water without opening the system. Those provisions are required to avoid conditions where temperature increases cause the ammonia vapor pressure over the aqua ammonia to exceed atmospheric pressure.

(c) An exhaust fan shall be installed to withdraw air from high points in the room and makeup air shall be allowed to enter at a low point.

(d) The aqua ammonia feed pump, regulators, and lines shall be fitted with pressure relief vents discharging outside the building away from any air intake and with water purge lines leading back to the headspace of the bulk storage tank.

(e) The aqua ammonia shall be conveyed direct from storage to the treated water stream injector without the use of a carrier water stream unless the carrier stream is softened.

(f) The point of delivery to the main water stream should be placed in a region of rapid, preferably turbulent, water flow.

(g) Provisions should be made for easy access for removal of calcium scale deposits from the injector.

(h) Provision of a modestly-sized scrubber capable of handling occasional minor emissions should be considered.

(3) Anhydrous ammonia

Anhydrous ammonia is readily available as a pure liquefied gas under moderate pressure in cylinders or as a cryogenic liquid boiling at -15 Celsius at atmospheric pressure. The liquid causes severe burns on skin contact.

(a) Anhydrous ammonia and storage feed systems (including heaters where required) shall be enclosed and separated from other works areas and constructed of corrosion resistant materials.

(b) Pressurized ammonia feed lines should be restricted to the ammonia room.

(c) An emergency air exhaust system, as in Section 6.4 but with an elevated intake, shall be provided in the ammonia storage room.

(d) Leak detection systems shall be fitted in all areas through which ammonia is piped.

(e) Special vacuum breaker/regulator provisions must be made to avoid potentially violent results of backflow of water into cylinders or storage tanks.

(f) Carrier water systems of soft or pre-softened water may be used to transport ammonia to the finished water stream and to assist in mixing.

(g) The ammonia injector should use a vacuum eductor or should consist of a perforated tube fitted with a closely fitting flexible rubber tubing seal punctured with a number of small slits to delay fouling by lime deposits.

(h) Provision should be made for the periodic removal of scale/lime deposits from injectors and carrier piping.

(i) Consideration shall be given to the provision of an emergency gas scrubber capable of absorbing the entire contents of the largest ammonia storage unit whenever there is a risk to the public as a result of potential ammonia leaks.

5.4.4 Ozonation

1. General

Ozone treatment systems may be used as a predisinfectant and as flocculation enhancement for water treatment facilities using surface water supplies. Piloting evaluations are required to determine ozone effectiveness and sizing for the proposed water treatment facility equipment. Bench testing may be used to determine initial ozone production requirements. Ozone piloting may be used in the pilot process or by contactor columns, based upon MassDEP determinations. The time frame for piloting of ozone treatment systems shall be the same as that approved for water treatment evaluations.

2. Piloting evaluations should address the following:

   a. The required contact time of ozone for maximum disinfection during period of high algal and bacteriological content should be addressed. EPA's *Surface Water Treatment Rule Guidance Manual* and the latest applicable EPA rules and guidance manuals shall be consulted for determining contact time values for inactivating pathogens including *Cryptosporidium*. The ozone decay rate for various application points shall also be evaluated.

   b. The effects of micro-flocculation from ozone on the treatment process (i.e., filter loading, flocculation, and settling characteristic changes) should be addressed. This evaluation shall include effects on disinfection by-products, filter turbidity effluent, and coagulant dose levels.

   c. Ozonation effects on constituents present in the raw water such as color, iron and manganese, volatile organic compounds, and organics (pesticides)

   d. Potential health effects of escaping ozone

   e. Corrosive effects of excess oxygen on facility internal piping

   f. Emergency power generator sizing due to ozone equipment addition

   g. Required ozone feed rate in milligrams per liter (mg/L). Maximum required gas application rates shall be determined during time periods with the least desirable water quality

   h. The feasibility and design requirements for applying ozone at other points in the treatment process

   i. The most appropriate application points. Ozone may be applied at one point or at multiple points in the process.

3. Ozonation Equipment

   a. Facilities using ozonation shall be designed to house all ozonation equipment in a separate room and to provide access for unit maintenance.

   b. The ozone treatment system shall be sized to provide sufficient capacity to provide a minimum dosage rate of 1.5 mg/L for the required flow unless piloting confirms a lesser rate.

   c. The application of ozone shall take place in a pretreatment contact tank sized to provide the maximum required CT as determined by piloting. Chambers shall consist of two dissolution chambers and a reaction chamber. A minimum of 2 feet of free clearance between the bottom of the chamber cover and the baffle wall shall be included. Gas will be placed in the contactor by fine bubble diffusors or by turbine dissolution.

d. Chambers shall be designed to provide a minimum of 10 minutes contact time of a at facility design flow. If iron and manganese oxidation is the primary purpose of ozone use, two chambers may be acceptable.

e. Chambers shall have gasketed stainless steel access hatches for periodic inspection.

f. Every ozone treatment train utilized for disinfection or other similar purposes shall have a means for determining if diffusers are properly operating. Acceptable methods may include:

(1) Observation windows with sufficient lighting within the chamber to allow daily visual inspection of ozone diffusion

(2) Provision to monitor the ozone transfer efficiency such as by continuous measurement of ozone off-gases and comparison with applied dose.

(3) Visual and audio alarms shall be provided and would be activated when ozone off gas set points are exceeded.

(4) Other methods as approved by MassDEP

g. Air preparation equipment shall be designed to minimize humidity during worst-case conditions. To ensure optimization of ozone generation and protection of equipment in all cases, design of air preparation equipment will include lowering the operating dew point to -60° C or lower. As a minimum, two towers be included in the air-drying process.

h. Flow of ozone gas to each chamber shall be by manual flow control valves. Excess and unused ozone gas shall be directed to a gas destruction system. The ozone gas destruction shall discharge to the atmosphere through a blower and vent stack system.

i. Ozonation equipment not used for disinfection may not need all of the above criteria as approved by MassDEP.

4. Equipment Design

Equipment shall be provided to meet existing design standards for application of this chemical and to ensure that adequate duplication is provided. Ozone gas preparation systems shall be designed to provide low, medium, or high pressure delivery systems. Heat generated in the gas stream during compression will be required to be within parameters determined by the manufacturer with use of an after cooler (if required).

Typical equipment to be provided with any ozone treatment system includes the following:

a. Air compressor using constant speed motors with excess capacity
Duplication may be required, due to the importance of this unit in the ozone distribution process.

b. Refrigerated air dryers with condensed water drains with excess capacity

Units shall be sized to handle maximum humidity conditions during worst-case summer periods.

c. Desiccant-bed air dryers used as the final air preparation system shall be designed to handle maximum dew point conditions from the refrigerated air dryers at the maximum expected moisture leading conditions.

d. Dry-air filters sized to meet maximum humidity conditions

e. Ozone generator with sufficient replacement tubes to ensure continued operation

f. Ozone diffusion equipment for each application point within the stages of the contact chambers

g. Off-gas, heat-assisted thermal/catalyst destruction unit and blowers

h. Main control panel and necessary air control instrumentation, including

   (1) Temperature-sensing indicators for inlet/outlet lines

   (2) Pressure-sensing indicators and transmitters for inlet/outlet lines

   (3) Vibration switches

   (4) Level and flow indicators

   (5) Alarm systems for high inlet pressure, high outlet cooling water, and low cooling water flow

i. Ozone concentration analyzer(s) and necessary laboratory equipment to determine ozone content in the feed stream, off-gas, and contact chamber

j. Spare parts for each component, including a complete set of dielectric tubes for at least one ozone generator

5. Safety and Training

a. Approval of ozonation treatment systems by MassDEP shall be contingent on the public water supplier providing a written plan that outlines classroom and training instruction for personnel on the ozone treatment system operation. The plan shall provide for training of operation and maintenance for the proposed ozone treatment plant prior to start-up.

b. Safety equipment shall be provided as required by the manufacturer and the local fire department.

c. Safety equipment shall consist of two ambient low-concentration ultraviolet absorption ozone photometer analyzers within the separate ozone building and at the contact chamber to measure atmospheric air. Gas masks and pressure-demand tanks shall be provided along with hand-operated gas detector devices.

d. Large signs indicating the presence of an irritant gas shall be located at all entrances to the ozone building.

e. Exhaust of ozone gas after the ozone destruct unit shall be below the accepted 8-hour exposure level at a point away from all building entrances. OSHA and industry standards shall be consulted for acceptable exhaust levels. Appropriate warning signs shall be placed at the exhaust point.

f. Emergency exhaust fans shall be provided in the room containing the ozone generators to remove ozone gas if leakage occurs.

g. Visual and audio alarms shall be provided for detection of ozone gas leakage.

6. Laboratory Equipment

The laboratory shall be specifically equipped with the necessary equipment for the operator to test and sample waters containing ozone gas. Sampling equipment shall be stainless steel, as required. Laboratory equipment shall consist of air sample diaphragm pumps, gas-washing bottles and absorbers, wet-test gas meters, a wall-mounted barometer, and equipment required for ozone determination as outlined in the latest edition of *Standard Methods for the Examination of Water and Wastewater.*

5.4.5 Chlorine Dioxide

1. Chlorine Dioxide Equipment

Chlorine dioxide equipment is similar to chlorine equipment. However, chlorine dioxide is produced in a chemically controlled manner on site due to its explosive nature.

a. The following pieces of equipment are required for chlorine dioxide generation:

(1) Reactor (Pyrex glass)

(2) Diaphragm metering pump

(3) Solution tank

(4) Mixer

(5) Chlorine dioxide generating tower

(6) Electrical controls, as needed

(7) PVC/Tygon and/or polyethylene piping

b. To prevent periods without disinfection or inadequate disinfection, automatic change-over equipment is necessary to switch chlorine gas supply as well as any of the associated reactants in use.

c. Chlorine dioxide may be tested by using the DPD or amperometric methods of analysis.

d. Where chlorine dioxide is required for protection of the supply, complete standby equipment of sufficient capacity shall be available to replace the largest unit during shutdown. Emergency power shall also be available.

2. On-Site Generation of Chlorine Dioxide

a. In liquid media, chlorine dioxide's production involves either of the following reactants:

(1) Chlorine and sodium chlorite

(2) Chlorite and hydrochloric acid

b. In gas phase generation, chlorine gas reacts with liquid sodium chlorite under vacuum. Chlorine dioxide is then removed by a gas ejector.

3. Dosage

a. The typical dosage of chlorine dioxide in drinking water varies from 0.1 mg/L to 0.5 mg/L with a maximum of 0.8 mg/L as ClO_2.

b. Continuous analyzers should be installed for monitoring and alarming of chlorine dioxide overfeeds.

4. Safety

Chlorine dioxide should be handled similarly to chlorine. The following precautions should be followed:

a. Chlorine dioxide cellular detectors should be installed in the area for continuous monitoring of chlorine dioxide leaks, if any. The drawtube of the equipment should be placed close to the floor.

b. In the event of an emergency, use self-contained breathing apparatus.

c. Chlorine dioxide mixtures should not be greater than 5%.

d. Due to the corrosive nature of sodium chlorite, the explosive nature of chlorine dioxide, and the fact that chlorine supports combustion in the event of a chlorine gas explosion, the chlorine dioxide facility (particularly the reactors) should be isolated from the rest of the facility, including supportive chlorinators.

e. The storage room should be adequately ventilated. Upon opening the door of the storage room, the exhaust fan should be automatically energized.

f. Chlorine dioxide leak detection equipment should be tested periodically for proper functioning.

g. Ammonia gas can be used to detect chlorine.

h. A formal safety program should be in place for personnel.

i. Audio and visual alarms shall be provided for detection of chlorine gas leakage.

5.4.6 Ultraviolet Disinfection

1. General

a. Ultraviolet (UV) light produced by UV lamps has been shown to be effective at inactivating protozoa (*Cryptosporidium* and *Giardia*) and bacteria (*Escherichia coli* and *Staphylococcus aureus*). It is less effective at inactivating certain types of viruses (adenovirus). UV light can be used as a disinfectant to meet the requirements of the SWTR (and all subsequent surface water treatment rules IESWTR, LT1SWTR, and LT2SWTR) and the Groundwater Rule (GWR).

b. MassDEP may on a case-by-case basis allow the use of UV light for disinfection of any type of source.

c. Unless otherwise approved by MassDEP, UV disinfection cannot be used alone when the source of microbial contamination is believed to be related to a problem in the distribution system. UV light may be used in conjunction with other acceptable forms of disinfection.

d. The information in this section establishes the minimum set of requirements for all systems using UV disinfection. Systems utilizing UV reactors for compliance with the SWTR, IESWTR, LT1SWTR, LT2ESWTR and GWR shall meet EPA's UV dose requirements (see Table 1 below) and perform reactor validation testing as summarized in Section 5.4.6.3 and detailed in the most recent EPA UV guidance document (November 2006, or most recent revisions).

Table 1 - UV Dose Requirements (mJ/cm^2)

	Log Inactivation							
	0.5	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**
Cryptosporidium	1.6	2.5	3.9	5.8	8.5	12	15	22
Giardia	1.5	2.1	3.0	5.2	7.7	11	15	22
Virus	39	58	79	100	121	143	163	186

e. These guidelines are for low pressure mercury vapor lamps (LP), low pressure high-output mercury vapor lamps (LPHO), and medium pressure mercury vapor lamps (MP). Other types of UV treatment (e.g. pulsed and eximer lamps) not covered in this section may be considered by MassDEP on a case-by-case basis and may require new technology approval.

2. Water Quality

a. UV disinfection effectiveness can be impacted by certain water quality parameters. Table 2 summarizes the minimum amount of monitoring that shall be conducted for systems utilizing UV reactors for compliance with the SWTR, IESWTR, LT1SWTR, LT2ESWTR and GWR. For all other situations, MassDEP may allow less frequent monitoring (e.g. one sample/year for any type of source). The samples shall be collected at a location that is immediately prior to where the UV reactor is to be installed. Water quality monitoring shall represent storm events, reservoir turnover, seasonal changes, source blending, and any variation in upstream treatment.

Table 2

Parameter	**Frequency** [(1)]	**Recommended Limits**
pH (field measurement)	Monthly	NA
Temp. (field measurement)	Bi-weekly for 1 year	NA
Dissolved iron (mg/L)	Quarterly for 1 year	0.1
Dissolved manganese (mg/L)	Quarterly for 1 year	0.05
Turbidity (NTU)	Bi-weekly for 1 year	1.0
Color (color units)	Monthly	15
Total Hardness (mg/L as $CaCO_3$)	Quarterly for 1 year	120
Hydrogen Sulfide[(2)] (mg/L)	Quarterly for 1 year	0.2
Alkalinity (mg/L as $CaCO_3$)	Quarterly for 1 year	NA
Suspended Solids (mg/L)	Quarterly for 1 year	10.0
UV Transmittance @ 254nm	Bi-weekly for 1 year	NA
Spectral Absorbance[(3)]	Bi-weekly for 1 year	NA
Algae Counts (cells/mL)[(4)]	Bi-weekly for 1 year	NA[5]

Notes:
(1) In some cases MassDEP may allow the use of historical data that was not collected at the frequency defined.
(2) Groundwater only
(3) For the use of medium pressure reactors only. Absorbance to be measured at 200 – 300 nm.
(4) Unfiltered supplies only.
(5) At algae concentration > 70,000 cells/mL additional piloting may be required as part of the UV validation testing.

b. MassDEP, the design engineer or the UV reactor manufacturer, may require additional treatment for waters that do not meet the recommended limits specified in Table 2.

3. Validation

The purpose of validation testing is to determine the operating conditions under which a UV reactor delivers the validated dose. The validated dose must be greater than or equal to the required dose (Table 1) to receive log inactivation credit for a target pathogen. Validation testing also establishes the operational set points used during reactor operations to confirm delivery of the validated dose. UV reactors being installed in order to comply with the disinfection requirements of the SWTR, IESWTR, LT1SWTR, LT2SWTR or GWR, shall be validated.

a. The proponent shall submit a Validation Test Plan to MassDEP for review and approval. The Validation Test Plan shall be accompanied by the appropriate MassDEP permit (BRP WS 21, Approval to Conduct Pilot Study) and a completed Validation Test Plan Checklist (See Checklist 5.2 in EPA’s UV Guidance Manual, November 2006, or most recent revision). At a minimum, the Validation Test Plan shall include the following:

(1) Description of UV reactor to be validated (wetted dimension, baffles, lamps, UV sensors, optical properties)

(2) Justification for the type of UV reactor to be validated

(3) Description of the validation test

(4) Description of the treatment process train where the UV reactor(s) is to be installed

(5) Key personnel, laboratories and institutions/companies overseeing the testing and preparation of the reports

(6) Validation testing schedule

(7) Discussion of the standard testing approach to be used (e.g. intensity set point approach, calculated dose approach)

(8) Operating parameters and ranges to be tested (flow, UV transmittance, lamp aging and fouling factors)

(9) Method of accounting for non-uniform lamp aging

(10) Description of all equipment (including analyzers and sensors) to be used

(11) Schematic of all equipment and piping (including pipe sizes, sample tap locations, meter(s), in-line analyzers, pump(s), valve locations)

(12) Description and justification of the non-pathogenic challenge organism(s) to be used

(13) Parameters to be monitored (flow, UV intensity, UV transmittance, lamp status, electrical power consumption, challenge organism concentration), and frequency of monitoring

(14) Wastewater disposal plan (for on-site validation testing only)

b. A full scale UV reactor validation test shall be done in accordance with EPA's latest UV Guidance Manual November 2006 (or most recent revisions). MassDEP may, pending EPA guidance, allow validation methods other than challenge organism biodosimetry techniques (e.g., computational fluid dynamics, microspheres).

c. UV reactors can be validated either off-site or on-site. Typically, off-site validation is done before installation at an approved testing facility. Reactors that are tested at an approved off-site facility that receive MassDEP validation approval for a specific installation are considered as 'prevalidated'.

d. The primary steps for the UV reactor validation test shall consist of the following:

(1) Bench-scale collimated beam test using the approved challenge microorganism(s)

(2) Full scale UV reactor test using the approved challenge microorganism(s)

(3) Determination of the reduction equivalent dose (RED)

(4) Derivation of the validation factor (VF)

(5) Calculation of the UV reactor's validated dose

e. UV reactor validation testing shall be overseen by a third party that is independent of the UV manufacturer and shall be competent in UV technology.

f. Once validation testing begins any changes or revisions are prohibited unless prior approval is obtained from MassDEP.

g. The proponent shall submit a validation report to MassDEP for review and approval. The report shall be accompanied by the appropriate MassDEP permit (BRP WS 22, Approval of Pilot Study Report) and a completed Validation Report Checklist (See Checklist 5.3 in EPA's UV Guidance Manual, November 2006, or most recent revisions). At a minimum, the validation report shall include the following:

(1) Executive summary stating the log credit achieved for the validated dose and range of operating conditions

(2) Summary of all test results, including collimated beam results

(3) All validation calculations (e.g. RED, VF)

(4) QA/QC checks

(5) Description of any variations in the actual validation test from MassDEP approved validation test plan

(6) Discussion on any potential impacts to or from upstream and downstream treatment processes

(7) Proposed schedule for final UV design submittal to MassDEP and anticipated installation date

b. Unless otherwise approved by MassDEP, the final UV design and installation shall be done with equipment and in a configuration identical to that which was used in the validation test. MassDEP reserves the right to require a UV reactor revalidation test should actual installed conditions vary significantly from that of the original validated test conditions.

4. Hydraulics

a. The minimum, maximum, and average flow rates shall be provided.

b. The expected pressure drop through the reaction chamber at maximum flow rate shall be provided.

c. The UV reactor chamber shall be fully enclosed and be plug flow. The reactor shall be flowing full under all hydraulic conditions. No open channel units shall be allowed.

5. Materials

a. The materials exposed to UV irradiation, including the piping and isolation valves immediately upstream and downstream of the reactor unit, shall be constructed of materials that are resistant to UV light. They shall not impart undesirable taste, odor, color, and/or toxic materials into the water as a result of the presence of toxic constituents in materials of construction or as a result of physical or chemical changes resulting from exposure from UV energy.

b. All components shall be constructed of materials suitable to withstand the temperatures generated during normal operation.

6. Design Criteria

a. For systems utilizing UV reactors for compliance with the SWTR, IESWTR, LT1SWTR, LT2ESWTR and GWR, the minimum UV dose ("reduction equivalent dose") shall be dictated by the corresponding desired log inactivation as defined in EPA's UV dose requirements (see Table 1 in Section 5.4.6.1.d). The reactor shall operate within the validated range 95% of the time each month in order to be in compliance.

b. All other UV reactors shall provide a minimum dosage of 40,000 microwatt-seconds per square centimeter (40 mJ/cm^2) unless a higher dosage is required by MassDEP.

c. The reactor must be certified to NSF/ANSI Standard 55 for Class A units.

d. The required minimum dosage shall be achieved by the unit at the manufacturer's specified end of lamp life. This minimum dosage shall be applied throughout the reaction chamber.

e. The selected UV reactor shall be capable of providing the required dosage under all hydraulic and water quality conditions

f. The UV reactor shall be designed to provide the specified minimum dosage at the peak instantaneous flow rate to be expected through the reactor. Automatic flow control devices may be required by MassDEP to ensure that the maximum design flow rate is not exceeded.

g. The estimated power consumption of the unit(s) under the design operating conditions shall be provided.

h. At least one redundant UV reactor shall be provided unless otherwise approved by MassDEP.

i. Each UV reactor shall be equipped with a minimum of one inline (“duty”) sensor and one spare (“reference”) sensor. The UV reactor shall be designed so that the duty sensor(s) can be readily removed and checked against the reference sensor(s). The UV sensor(s) shall meet the following criteria:

   (1) The duty sensor shall be installed in the wall of the disinfection chamber at the point of greatest distance from the lamps.

   (2) Documentation shall be provided that demonstrates that all sensors meet the National Institute of Standards & Technology (NIST) traceable measurements with an uncertainty of $\pm$ 15% or less at an 80% confidence level.

   (3) The duty sensor shall continuously measure the UV intensity produced by the lamp(s) and be provided with a unit mounted UV intensity meter. For units equipped with more than one sensor, the meter shall display the average percent intensity based upon the Point Source Summation (PSS) method.

   (4) Intensity meters shall display numerical UV intensity values ranging from zero to one hundred. Intensity meters that indicate LOW, MEDIUM, or HIGH UV intensity are <u>not acceptable</u>.

   (5) Sensors and intensity meters shall be properly calibrated to account for lamp geometry.

j. At least one inline UV transmittance monitor shall be installed upstream of the UV treatment for all systems that are complying with the SWTR, IESWTR, LT1SWTR, LT2ESWTR and GWR. MassDEP may allow grab samples in lieu of a continuous monitor in situations where water quality does not vary.

k. The system shall have ground fault interrupt circuitry and it shall be installed on a designated electrical circuit.

l. The reactor shall be designed to prevent short-circuiting.

m. Lamps shall be enclosed in quartz sleeves in order to maintain the lamp surface near its optimum operating temperature.

n. Lamp assemblies shall be insulated from direct contact with the influent water.

o. Lamp sleeves shall be annealed to remove internal stress.

p. The UV reactor shall be designed to permit either mechanical or physical cleaning of the quartz sleeve.

q. Each UV reactor shall be provided with an elapsed time meter, which accurately monitors the hours that the unit’s lamp is on.

r. Power and/or voltage interruptions shall be avoided. The UV reactor shall be designed with an electrical interlock such that it will automatically stop water flow in the event of a power failure and/or voltage interruption. The unit shall go back on line only when adequate UV intensity has been restored.

s. The UV reactor shall be provided with an audible and visual alarm set to go off and trigger flow shut-down during the following scenarios:

  (1) The UV intensity monitor indicates that insufficient UV light (as specified in item 1 or 2 above is reaching the sensor.

  (2) Lamp or ballast failure

  (3) Mechanical wiper failure (if applicable)

  (4) The hour meter indicates that the useful life of the bulb as recommended by the manufacturer has expired.

  (4) High reactor temperature

t. An early warning alarm shall be provided for both the intensity meter and hour meter, to notify the operator when either the minimum design dosage (as specified in item 1 or 2 above) or the useful life of the bulb is within 10% of the shut down set points. This alarm is not required to shut the system down.

u. In situations where gravity flow through the unit exists, the system shall either have provisions for automatic emergency power or automatic flow shut down in the event of power failure.

v. If the UV reactor is installed for reasons other than compliance with the SWTR, IESWTR, LT1SWTR, LT2ESWTR and GWR, and it is the only form of disinfection used in a community system, redundancy may be required by MassDEP. This secondary or back-up form of disinfection should be installed and ready for operation if the primary UV reactor fails or is taken off-line.

7. Installation

  a. The UV reactor design must be approved by MassDEP prior to reactor installation.

  b. The UV reactor shall be installed in a protected enclosure not subject to extremes of temperature that could cause malfunction.

  c. Each UV reactor shall have the capability of being easily isolated or taken out of service for replacement or repair. Bypass lines around the reactor are not allowed.

  d. Any UV reactor that is installed, and is in a ‘standby’ mode shall be either physically disconnected from the process piping or be equipped with an open drain vent so as to prohibit any flow from a leaking valve to pass through the reactor.

e. If the UV reactor is installed in an area that is normally unattended (i.e. basement, utility room etc.) the alarm (see Section 5.4.6.6.s) should be located in an area that is occupied by personnel familiar with the alarm and the procedures to report the alarm.

f. Unless otherwise approved by MassDEP, there shall be a minimum of 5 pipe diameters of straight pipe upstream and downstream of each UV reactor.

g. Unless otherwise approved by MassDEP, validated reactors must be installed in an identical configuration at the facility as was tested during validation.

h. A smooth-nosed sampling tap shall be installed upstream and downstream of each UV reactor.

i. Unless otherwise approved by MassDEP, each UV reactor shall be equipped with a dedicated flow meter.

j. The UV reactor is installation configuration should allow ease of access for disassembly, repairs, and replacement.

8. Spare Parts

a. All UV reactors installed for compliance with the SWTR, IESWTR, LT1SWTR, LT2ESWTR and GWR shall have spare parts as described in section 6.3.3 of EPA's UV Guidance Manual, November 2006, or most recent revisions.

b. All other reactors consisting of only a single unit shall be supplied with a spare lamp, spare electrical ballast, and a spare reference sensor.

c. Spare lamps shall conform to the original lamp specifications.

9. Maintenance

a. An operation and maintenance manual including a parts list and parts order form shall be supplied to the owner/operator of the UV reactor. The operations and maintenance manual shall be submitted to MassDEP for approval before the UV reactor goes on-line. The manual shall conform to MassDEP Policy 93-02 (Operation and Maintenance Manual) and these guidelines (see Section 5.1.6.1.c).

b. At a minimum, the operation and maintenance manual shall address the following:

(1) Procedures for routine cleaning of the quartz sleeve and sensor window (manual or automatic sleeve cleaning, with or without chemicals)

(2) Procedures and recommended frequency for calibrating the intensity meter for proper intensity

(3) Procedures and recommended frequency of UV transmittance monitor calibration

(4) Procedures for changing lamps, sleeves, and sensors

(5) Procedures and recommended frequency of sensor calibration

(6) Procedures and recommended frequency of dedicated flow meter calibration

(7) Guidance on the proper care and handling of lamps to prevent injury and inadvertent lamp breakage

(8) Method of lamp disposal

(9) Procedures for storage and disposal of quartz sleeve cleaning chemicals. (if using chemical cleaning method)

(10 Emergency procedures should a lamp break while in service

c. Public water systems installing UV reactors in order to comply with the requirements of the SWTR, IESWTR, LT1SWTR, LT2ESWTR and GWR shall perform routine maintenance as outlined in Section 6.3 of EPA's UV Guidance Manual, November 2006, or most recent revisions. For all other UV reactors, the following minimum maintenance shall be performed:

(1) The duty sensor shall be checked against the reference sensor at least every six months.

(2) The quartz sleeve shall be checked every month and cleaned/replaced as necessary.

(3) The lamps shall be replaced at least every year.

(4) Quartz sleeves shall be replaced every 5 years.

d. The operation and maintenance manual shall include a separate section that describes the actions required to insure the delivery of treated water in the event of a failure of the UV reactor.

10. Reporting Requirements

a. All UV reactors installed for compliance with the SWTR, IESWTR, LT1SWTR, LT2ESWTR and GWR, shall submit the necessary monthly reports to MassDEP that demonstrates that 95% of the water treated (by volume) was within the approved validated specifications. At a minimum, the following data for each UV reactor must be submitted:

(1) Required UV dose

(2) Daily run time

(3) Daily volume of water treated

(4) Daily maximum flow rate

(5) Minimum UV transmittance

(6) Minimum UV intensity

(7) Actual validated dose

(8) Volume of water that was off-specification

b. For any UV reactor installed for compliance with the SWTR, IESWTR, LT1SWTR, LT2ESWTR and GWR that was off-specification for any period during a month, an additional monthly report must be submitted that calculates the total monthly volume of treated water that was off specification as a percentage of the total volume of treated water for the month.

c. All other systems with UV reactors must submit a monthly report that includes the daily volume of water treated and a daily UV intensity reading.

d. Records regarding routine equipment calibration and maintenance must be maintained at the treatment facility and be made available to MassDEP upon request.

5.5 Aeration

5.5.1 General information

1. Uses

Aeration may be used to help remove offensive tastes and odors due to dissolved gases from decomposing organic matter, or to reduce or remove objectionable amounts of carbon dioxide, hydrogen sulphide, etc., and to introduce oxygen to assist in iron and/or manganese removal. Aeration may be used for other treatment needs, such as to remove volatile organic compounds, to remove carbon dioxide for pH control, and to remove radon. Aeration units intended to be used to remove TCE must conform to DWS Policy 88-01 – Air Stripper Policy. See also 90-04 for piloting requirements for VOC removal through aeration. A non-DWP permit may be required. The water system should contact the Bureau of Waste Prevention for further information.

The design of aeration units shall be of a type acceptable to MassDEP.

2. Protection of Aerators

All new aerators shall be protected from contamination from birds and insects, windblown debris, rainfall, and water draining from the exterior of the aerators. Existing aerators lacking this protection shall be retrofitted.

3. Disinfection

Groundwater supplies exposed to the atmosphere by aeration shall be properly disinfected (see section 5.4.1.1).

4. Bypass

   A bypass should be provided for all aeration units.

5.5.2 Natural Draft Aeration

The design shall specify:

1. For distribution of water uniformly over the top tray
2. Construction of durable material resistant to aggressiveness of the water and dissolved gases
3. Protection from loss of stray water by wind carriage by enclosure with louvers sloped to the inside at an angle of approximately 45 degrees

5.5.3 Forced or Induced Draft Aeration

Devices shall be designed to:

1. Include a blower with a weatherproof motor in a tight housing and screened enclosure
2. Ensure adequate counter current of air through the enclosed aerator column
3. Exhaust air directly to the outside atmosphere
4. Include a down-turned and 24-mesh screened air outlet and inlet
5. Introduce air in the column that shall be as free from fumes, dust, and other contaminants as possible
6. Allow sections of the aerator to be easily reached or removed for maintenance of the interior or be installed in a separate aerator room
7. Provide distribution of water uniformly over the top tray
8. Be of durable material resistant to the aggressiveness of the water and dissolved gases
9. Provide for proper air to water ratios to insure effective removal of targeted contaminants

5.5.4 Pressure Aeration

Pressure aeration may be used for oxidation purposes only if pilot plant study indicates the method is applicable. Pressure aeration devices shall be designed to:

1. Give thorough mixing of compressed air with water being treated

2. Provide screened and filtered air free of fumes, dust, dirt, and other contaminants

5.5.5 Other Methods of Aeration

Such methods include but are not restricted to spraying, diffused air, cascades and mechanical aeration. The treatment process shall be designed to meet the particular needs of the water to be treated and shall be subject to the approval of MassDEP.

5.6 IRON AND MANGANESE CONTROL

5.6.1 General Information

Iron and manganese control, as used herein, refers solely to treatment processes designed specifically for this purpose unless otherwise approved by MassDEP. The treatment process used will depend upon the character of the raw water. The selection of one or more treatment processes must consider specific local conditions as determined through engineering investigations including chemical analysis of representative samples of water to be treated and must receive the approval of MassDEP. It may be necessary to operate a pilot plant in order to gather all information pertinent to the design. Consideration should be given to adjusting pH of the water to optimize the chemical reaction.

If the manganese concentrations in raw water exceeds 0.3 mg/L but are less than 1.0 mg/L, an assessment by MassDEP Office of Research and Standards will be necessary to determine if removal shall be required. If manganese concentrations in raw water exceed 1.0 mg/L, removal is required. If iron, manganese, or a combination thereof exceeds 1.0 mg/L, removal is required.

Smooth-nosed sampling taps shall be provided for control purposes. Taps shall be located on each raw water source, each treatment unit influent and each treatment unit effluent.

Testing equipment shall be provided for all plants or arrangements made for testing by a Massachusetts or EPA certified lab as required by MassDEP.

5.6.2 Removal by Oxidation, Detention, and Filtration

1. Oxidation

   Oxidation may be by aeration, as indicated in Section 5.5 or by chemical oxidation with chlorine or potassium permanganate or other approved chemical.

2. Detention

   a. Reaction - A minimum detention of 30 minutes shall be provided following aeration in order to insure that the oxidation reactions are as complete as possible. This minimum detention shall be omitted only where a pilot plant study indicates no need for detention. The detention basin shall be designed as a holding tank with no provisions for sludge collection but with sufficient baffling to prevent short circuits.

b. Sedimentation - Sedimentation basins shall be provided where chemical coagulation is used to reduce the load on the filters or where indicated by pilot plant study.

3. Filtration

Filters shall be provided and shall conform to Section 5.3.

5.6.3 Removal by Manganese Greensand Filtration

This process is more applicable to the removal of manganese than to the removal of iron.

1. Provisions should be made to apply the permanganate as far ahead of the filter as practical and to a point immediately before the filter.
2. Other oxidizing agents or processes such as chlorination or aeration may be used prior to the permanganate feed to reduce the cost of the chemical.
3. Anthracite media cap of at least 6 inches shall be provided over manganese greensand.
4. Normal filtration rate is 3 gal/min/ft^2.
5. Normal wash rate is 8 to 10 gal/min/ft^2.
6. Air washing should be provided.
7. Sample taps shall be provided:
   a. prior to application of permanganate
   b. immediately ahead of filtration
   c. at a point between the anthracite media and the manganese greensand
   d. halfway down the manganese greensand
   e. at the filter effluent

5.6.4 Removal by Ion Exchange

This process of iron and manganese removal should not be used for water containing more than 0.3 mg/L of iron, manganese, or a combination thereof unless otherwise approved by MassDEP. This process is not acceptable where either the raw water or wash water contains dissolved oxygen unless otherwise approved by MassDEP. Care should be taken to avoid producing water containing high sodium concentrations. Reference latest Office of Research and Standards (ORS) guidance for sodium concentrations (see Section 5.8.5).

5.6.5 Sequestration by Phosphates

This process shall not be used when iron, manganese, or a combination thereof exceeds 1.0 mg/L. If the manganese concentrations in raw water exceed 0.3 mg/L but is less than 1 mg/L, an assessment by MassDEP Office of Research and Standards will be necessary to determine if removal is required. The total phosphate applied shall be related to the amount of iron and manganese to be sequestered. It shall not exceed 4 mg/L as PO_4, except 10 mg/L may be allowed until the system becomes stabilized as evidenced by presence of 4 mg/L at the extremity of the system. Flushing of the distribution system prior to initial treatment is recommended to accelerate the stabilization.

1. Feeding equipment shall conform to the requirements in Section 6.0.

2. Stock phosphate solution must be kept covered and disinfected by carrying approximately 10 mg/L free chlorine residual in the phosphate barrel. This guideline applies unless it can be shown that the pH or the chemical composition of the phosphate prevents microbiological growth. Chlorine should not be added to the phosphate barrel when the phosphate contains zinc.

3. Polyphosphates shall not be applied ahead of iron and manganese removal treatment. The point of application shall be prior to any aeration, oxidation, or disinfection if no iron or manganese removal treatment is provided.

4. Phosphate chemicals must be food grade and approved by MassDEP.

5. Plans for the specific installation must be approved by MassDEP prior to installation.

6. A phosphate proposed for use as a sequestering agent must be evaluated with respect to its impact on corrosion control (see Section 5.8).

7. Changes in chemicals used for sequestering require MassDEP approval and may require submittal of a pilot proposal and pilot report for MassDEP approval (see Section 5.1.5.1.o).

5.7 Fluoridation

5.7.1 Plans, Specifications, and Coordination with Massachusetts Department of Public Health (DPH))

MassDEP will review and approve all engineering plans and specifications for fluoride feed equipment. The appropriate permit application, along with the plans and specifications must be completed and submitted to the appropriate MassDEP regional office for approval. Construction of the facility shall begin within three years of the date of the permit approval. After this date a new permit application must be resubmitted to MassDEP for a new approval. Included within the permit approval letter (DPH, Office of Oral Health copied) will be a requirement that a DPH (Office of Oral Health) approved fluoride monitoring plan be submitted to the water supplier and MassDEP (see Section 5.7.7) before MassDEP will consider allowing the facility to go on-line.

After construction has been completed the MassDEP regional office will inspect the completed facility while the facility is pumping to waste with approved fluoridation works and appurtenant works in operation. Initial sampling and analysis for fluoride concentration of fluoridated water while pumping to waste will be conducted by the water supplier under observation by MassDEP. The water supplier shall use calibrated approved fluoride analyzers. The target fluoride concentration is 1.0 ppm with an acceptable range of 0.9 ppm-1.2 ppm. If the facility is operating properly and initial sampling for fluoride concentration is within the acceptable range, the facility will be conditionally placed on line. Immediate follow-up sampling and analysis of water entering the distribution system will then be conducted by the water supplier under observation by MassDEP. If fluoride concentrations are still within the acceptable range, MassDEP will give written approval within five days to place the facility permanently on-line; DPH approved monitoring plan will be implemented without delay. If the test results are not within the acceptable range, the facility will not be allowed to go permanently on-line until test results show are in the acceptable range. The DPH (Office of Oral Health) will be copied on this approval letter.

5.7.2 Fluoride Compound Storage

Compounds shall be stored in covered or unopened containers and should be stored inside a building. Unsealed storage units for hydrofluosilicic acid should be vented to the atmosphere at a point outside the building.

5.7.3 Fluoride Chemicals, Chemical Feed Equipment and Methods

Commercial sodium fluoride, sodium silicofluoride, and hydrofluosilicic acid shall conform to the applicable AWWA standards and NFS 60.

In addition to the requirements in Chapter 6, fluoride feed equipment shall meet the following requirements:

1. General

    a. Scales or loss-of-weight recorders shall be provided for sodium silico-fluoride dry chemical feeders and hydrofluosilicic acid day tanks.

    b. To avoid loss of fluoride, the fluoride compound shall not be added before filtration if aluminum coagulants are used. If a clearwell is provided, the fluoride compound should be added to the filter effluent or clearwell influent for better mixing and to guard against overfeeding.

    c. Adequate anti-siphon devices shall be provided for all fluoride feed lines.

    d. If a protected water flush or carry water tee is provided, it shall only be teed in on the metering pump discharge line within 10 feet of the final fluoride injection point to help avoid slug feeding. An interlock solenoid valve is required.

    e. See also Chapter 6.

2. Fluoride Metering Pumps

   a. Feeders shall be accurate to within 5% of any desired feed rate.

   b. The fluoride feeder must be paced in proportion to flow if the flow varies in excess of 10% of normal flow.

   c. Two diaphragm-type anti-siphon valves shall be installed in the fluoride feed line when a metering pump is used. The anti-siphon device should have a diaphragm that is spring-loaded in the closed position. All anti-siphon devices shall be dismantled and visually inspected at least once a year and replaced if necessary. Schedules of repairs or replacements should be based on the manufacturer's recommendations.

   d. All fluoride-metering pumps shall be constructed so that the pumps cannot remain in "hand or manual" mode unless the switch is held in place by an operator.

   e. All new or modified fluoride-metering pumps shall be electrically interlocked with respective raw or treated water pump or a thermal type flow switch drilled into the pipeline. Any newly installed hard wired interlocked circuit shall include a pilot light located near the fluoride pump that indicates when the interlocked circuit is activated.

   f. A fluoride solution shall be applied by a positive displacement pump having a stroke rate not less than 20 strokes per minute.

3. Sodium Fluoride Saturators

   a. The service water solution shall be metered for sodium fluoride saturators.

   b. The water make-up line to an upflow saturator shall be equipped with a backflow prevention device approved by MassDEP.

   c. An external saturator overflow prevention system shall be installed on the water make-up line to avoid overflows. A non-electrical hydraulic type float valve placed in a fixed six-gallon overflow container is acceptable.

   d. The fluoride feeder should be located on a shelf or saturator top not more than 3 feet higher than the saturator or day tank. The suction line shall be as short as possible and slope continuously upward with no false loops. A flooded suction line is not recommended in water fluoridation to guard against possible siphoning.

4. Hydrofluosilicic Acid

   a. The point of application of hydrofluosilicic acid, if into a horizontal pipe, shall be in the lower half of the pipe.

   b. A day tank is required where bulk storage of hydrofluosilicic acid is provided.

   c. When hydrofluosilicic acid is transferred from a bulk storage tank to a day tank using a transfer pump, the following guidelines shall be implemented:

(1) To prevent siphoning, the transfer pump discharge line must extend up to a point above the height of the top of the bulk tank and must be teed back at its highest point to the bulk tank; a second choice is to add a back-pressure valve at the highest point of the discharge line.

(2) The fill switch shall be momentary type (spring loaded switch) so as not to pump continuously and shall be hand-held in "on" position or else it would stop pumping.

(3) The daytank cover shall be fitted with a high level probe to shut off the transfer.

d. When hydrofluosilicic acid is transferred from a bulk storage tank to a daytank, the preferred method of transfer is by means of a transfer pump, but if gravity feed is utilized then two spring loaded ball valves shall be installed in series in the line between the two tanks.

5.7.4 Protective Equipment

At least one pair of rubber gloves, a respirator certified by the National Institute for Occupational Safety and Health for toxic dusts or acid gas (as necessary), an apron, or other protective clothing, and goggles or face masks shall be provided for each operator. Other protective equipment must be provided as necessary.

5.7.5 Dust Control

1. Provision shall be made for the transfer of dry fluoride compounds from shipping containers to storage bins or hoppers in such a way as to minimize the quantity of fluoride dust which may enter the room in which the equipment is installed. The enclosure shall be provided with an exhaust fan and dust filter which maintains the hopper under a negative pressure. Air exhausted from fluoride handling equipment shall discharge through a dust filter to the outside atmosphere of the building.

2. Provision shall be made for disposing of empty bags, drums, or barrels in a manner which will minimize exposure to fluoride dusts. A floor drain or vacuum cleaner shall be provided to facilitate the cleaning of floors.

5.7.6 Testing Equipment

Equipment shall be provided for measuring the fluoride concentration in the finished water. Public water system operators using their own fluoride analyzers must use analytical equipment and methodologies approved by the Mass DEP in compliance with the latest Mass DEP fluoridation guidelines and 310 CMR 22.06(16)(b) and 310 CMR 22.10. Analytical equipment such as specific ion or colorimetric, used by operators should be portable and must be calibrated on a daily basis prior to use.

5.7.7 Fluoride Monitoring

Public water systems are required to monitor for fluoride by MassDEP Drinking Water Program and DPH Office of Oral Health.

1. MassDEP Role

   MassDEP/DWP oversees and enforces all SDWA requirements and the public water system fluoride monitoring program. MassDEP requires monitoring for fluoride in both fluoridated and non-fluoridated public water sytems at points of entry to the distribution system. SDWA compliance monitoring for fluoride is required only for community systems, however, MassDEP reserves the right to assess and take action on fluoride levels of concern in any public water system. Community systems must be in compliance with the relevant portions of 310 CMR 22.00 and in particular 310 CMR 22.06, 22.06C and 22.16(4).

   MassDEP approves the sampling locations at the point(s) of entry into the distribution system and frequency of sampling. Samples are collected by public water system operators according to MassDEP approved sampling schedule and sent to laboratories certified by MassDEP for fluoride analysis. Reports containing fluoride results are sent to MassDEP within 10 days of the end of the reporting month.

   MassDEP also requires, as part of the New Source Approval process, monitoring for fluoride concentrations in all new public water supply sources.

2. DPH Role

   The DPH, Office of Oral Health, following the US Centers for Disease Control and Prevention (CDC**)** recommendations, supervises the non SDWA fluoride monitoring program. DPH requires monitoring for fluoride in fluoridated PWSs *and* PWSs with naturally occurring fluoride concentrations at optimum levels or higher. DPH may also require baseline monitoring for NTNCs such as schools.

   DPH requires the following monitoring protocol for PWSs that fluoridate:

   a. Daily monitoring is required at MassDEP approved entry points to the distribution system. The PWS operator(s) may use their own fluoride analyzers to monitor or collect samples and send to a Massachusetts certified laboratory certified for fluoride analysis.

   b. Weekly monitoring must be conducted a minimum of four times a month at DPH approved sampling locations in the distribution system. Monitoring shall be conducted by the PWS operator(s) using their own fluoride analyzers or the PWS can send samples to a Massachusetts certified laboratory certified for fluoride analysis. These distribution sites shall be rotated as approved by DPH. Distribution sampling locations shall include a site near a school and, if applicable, sites selected or otherwise approved by DPH in the distribution system or a consecutive system.

   c. Monthly monitoring of monthly split sample(s) must be collected by the PWS operator(s) from DPH approved designated distribution locations and then sent to a Massachusetts certified laboratory certified for fluoride analysis. If the PWS used a

Massachusetts certified laboratory for its daily samples, it must send the required monthly split sample to a different Massachusetts certified laboratory.

All DPH required fluoride monitoring reports from PWS operators and certified labs must be sent to the Office of Oral Health, Mass. DPH within 10 days of the end of the reporting month on DPH approved forms.

5.8 Corrosion Control

5.8.1 General Information

Water systems that exceed the lead and/or copper action levels shall install and operate optimal corrosion control treatment in accordance with 310 CMR 22.06B of the Massachusetts Drinking Water Regulations. Chemicals proposed for use in corrosion control must be thoroughly evaluated and are subject to DEP review and approval before use. With the application of chemicals MassDEP may require some or all of the following: desk top study, bench scale study, pilot study proposal, pilot testing, pilot report, or new technology approval (see Sections 5.1.5.1.o, 5.6.5.6, and 5.8.1).

Laboratory equipment or laboratory service shall be provided to maintain adequate control.

Smooth-nosed sampling taps shall be provided for control purposes. Taps shall be located on each raw water source, each treatment unit influent, and each treatment unit effluent.

Corrosion of pipes can be controlled primarily through use of corrosion inhibitors and/or adjustment of pH and alkalinity; alternatively, other means such as calcium hardness adjustment may be utilized.

5.8.2 Corrosion Inhibitors – Phosphates & Silicates

The feeding of phosphates and silicates may be applicable for corrosion control.

1. Feed equipment shall conform to the requirements in Chapter 6.

2. Phosphate must be certified by NSF 60 and approved by MassDEP.

3. Stock phosphate solution must be kept covered and disinfected by carrying approximately 10 mg/L free chlorine residual in the phosphate tank. This guideline applies unless it can be shown that the pH or the chemical composition of the phosphate prevents microbiological growth. Chlorine should not be added to the phosphate tank when the phosphate contains zinc.

4. Some phosphate applications may require water to have a pH restricted to a narrow range for its most effective use, e.g. pH 7.2 - 7.8.

5. Presence of other chemicals in water like disinfection by-products may compromise the effectiveness of phosphates in controlling pipeline corrosion.

5.8.3 pH & Alkalinity Adjustment - Chemicals

The use of lime, soda ash, sodium hydroxide, potassium hydroxide, sodium bicarbonate, and potassium carbonate may be applicable for adjustment of pH and alkalinity for corrosion control (see Section 5.8.1).

5.8.4 pH Adjustment - Aeration

Aeration of water containing significant concentrations of carbon dioxide may be an effective means of reducing carbon dioxide levels thereby raising pH and reducing chemical costs (see Section 5.5.1.1).

5.8.5 Other Treatment & Sodium Levels

Other treatment for controlling corrosive waters may be used where appropriate and approved by MassDEP. Although sodium is regulated as a secondary standard, the public water supplier should evaluate the total sodium level of the water delivered to the customer when considering adding a corrosion control chemical.

Chemicals that have not been previously used in Massachusetts public drinking water supplies may require new technology approval and must receive approval from MassDEP before use (see Section 5.1.5.1.o).

5.9 Taste and Odor Control

5.9.1 General Information

Space should be allocated for the future addition of taste and odor control chemicals at all surface water treatment plants; space should also be provided at all ground water treatment plants if needed. These chemicals should be added sufficiently ahead of other treatment processes to assure contact time for an effective and economical use of the chemicals.

5.9.2 Flexibility

Plants treating water that is known to have taste and odor problems should be provided with equipment that makes several control processes available so that the operator will have flexibility in operation.

5.9.3 Chlorination

Chlorination can be used for the removal of some objectionable odors. Adequate contact time must be provided to complete the chemical reactions involved.

5.9.4 Chlorine Dioxide

Chlorine dioxide has been generally recognized as a treatment for tastes caused by industrial wastes, such as phenols. However, chlorine dioxide can be used in the treatment of any taste and odor that is treatable by an oxidizing compound. When used provisions shall be made for proper storing and handling of the sodium chlorite so as to eliminate any danger of explosion. (see Section 5.4.5).

5.9.5 Activated Carbon

1. Powdered Activated Carbon

    a. Powdered activated carbon may be added prior to coagulation to provide maximum contact time. Facilities that allow the addition at several points are preferred. Activated carbon should not be applied near the point of chlorine application.

    b. The carbon can be used as a pre-mixed slurry or by means of dry-feed machine as long as the carbon is properly wetted.

    c. Agitation is necessary to keep the carbon from depositing in the slurry storage tank.

    d. Provision shall be made for adequate dust control.

    e. The required rate of feed for carbon in a water treatment plant depends upon the tastes and/or odors involved, but provision should be made for adding from 0.1 mg/L to at least 40 mg/L.

2. Granular Activated Carbon Adsorption Units

    Refer to Section 5.3.2 Filter Media, 10 c.

5.9.6 Copper Compounds and Other Algaecides

The application of algaecides including copper containing compounds (such as copper sulfate), to a surface water body can be used to control taste and odor causing algae. All algaecide applications must be done by a Massachusetts licensed pesticide applicator in accordance with the USEPA Federal Insecticide, Fungicide and Rodenticide Act of 1996. In addition, MassDEP must be notified in writing prior to the application of such algaecides (310 CMR 22.20B(8)). For non-copper containing algaecides, a MassDEP permit must be issued. Copper containing compounds shall be controlled to prevent copper concentrations in excess of 1.0 mg/L in the plant effluent. Care shall be taken to assure an even distribution.

5.9.7 Aeration

Refer to Section 5.5.

5.9.8 Potassium Permanganate

Application of potassium permanganate may be considered, providing the treatment shall be designed so that the products of the reaction are not present in the finished water.

5.9.9 Ozone

Ozonation can be used as a means of taste and odor control. Adequate contact time must be provided to complete the chemical reactions involved. Ozone is generally more desirable for treating water with high threshold odors (see Section 5.4.4).

5.9.10 Other Methods

The decision to use any other methods of taste and odor control should be made only after careful laboratory and/or pilot plant tests and on consultation with MassDEP.

5.10 Waste Handling and Disposal

5.10.1 General Information

1. Most water treatment facilities will produce one or more of the following wastes:

    a. Sanitary waste from areas such as kitchens, bathrooms and locker rooms

    b. Process and instrumentation waste from things such as continuous analyzers and sampling sinks

    c. Sediment and debris from periodic cleaning of intake structures or holding/equalization tanks

    d. Clarification process waste

    e. Filter backwash waste

    f. Membrane cleaning waste

    g. Filter media waste from periodic scraping or removal of media

    h. Building floor drain waste

    i. Hazardous chemical spill containment area waste

    j. Radioactive waste

    k. Any waste not listed above but which MassDEP requires be addressed

Some of these wastes, such as that from the clarification and filter backwash process, are commonly referred to as 'residuals' and can be further processed and disposed of (either off-site or on-site) in a number of ways discussed further in this section.

2. All WTPs must submit a Waste Disposal Plan that describes how each applicable waste stream listed in (1) above will be handled. The Waste Disposal Plan shall minimize the generation of material by emphasizing reuse, reduction, or recycling whenever feasible. The Waste Disposal Plan must minimize any potential contamination of the water supply by not proposing for waste disposal at a site which would be out of compliance with MassDEP regulations, policies, or guidelines governing protective areas of drinking water sources. The Waste Disposal Plan must be submitted as part of the WTP design and must be approved by MassDEP concurrently with the WTP design.

3. For WTPs producing residuals, the Waste Disposal Plan must contain a detailed Residuals Management Plan. The Residuals Management Plan must use information obtained during the pilot study to qualify and quantify the type, and amount, of residuals to be produced. The Residuals Management Plan must also provide a feasibility analysis of all temporary and final disposal options.

   The Residuals Management Plan must address the following:

   a. The plan must include a schedule of inspections, preventative maintenance, and data collection sufficient to assure that the collection and processing of residuals occurs in a manner that does not interfere with optimal treatment of water to customers **and** that the processing of residuals occurs in a manner consistent with all regulations and permits.

   b. The plan must include criteria which would trigger the water system to take actions such as when to dispose of collected residuals and outline what steps must be taken in order to effect that disposal including options for such disposal. This may include sampling and analyses of residuals, costs associated with residuals management, and residual disposal options available.

4. All waste discharges, either to the sewer, ground or surface water, are governed by one or more of the applicable federal, state, and local regulatory agency requirements. All necessary federal, state, and local permits must be obtained prior to the WTP going on line. The guidelines outlined herein are considered to be the minimum requirements as federal and local authorities may have more stringent requirements.

5.10.2 Facility Wastes

1. Sanitary Waste

   The sanitary waste from water treatment plants, pumping stations, etc., may be discharged directly to a sanitary sewer system when feasible or to *another* disposal facility approved by MassDEP or the appropriate wastewater permitting authority.

2. Brine Waste

Brine waste shall be discharged in a manner and a location approved by MassDEP or the appropriate wastewater permitting authority. Brine waste shall not be discharged in the Zone 1 or Zone A of a public water supply unless otherwise approved by the MassDEP.

Waste from ion exchange plants, demineralization plants, or other plants which produce brine, may be disposed of by controlled discharge to a stream if adequate dilution is available. Surface water quality requirements of the regulatory agency will control the rate of discharge. Except when discharging to large waterways, a holding tank of sufficient size should be provided to allow the brine to be discharged over a twenty-four hour period. Where discharging to a sanitary sewer, a holding tank may be required to prevent the overloading of the sewer and/or interference with the waste treatment processes. The effect of brine discharge to sewage lagoons might depend on the rate of evaporation from the lagoons.

3. Residuals

   a. Removal
      Design shall provide that:

      (1) Residuals withdrawal lines should be adequately sized for proper use. It is recommended they be at least 4 inches in diameter and arranged to facilitate cleaning.

      (2) Entrance to residuals withdrawal piping shall minimize clogging.

      (3) Valves shall be located outside the tank for accessibility.

      (4) The operator may observe and sample residuals being withdrawn from the unit.

   b. Handling
      Lagoons, Sanitary Sewer, Holding Tanks, and Mechanical Concentration

      (1) Lagoons may be used as a method of handling residuals. Lagoon size may be calculated using piloting data or known quantities from existing data. When selected for design, lagoons shall have the following minimum features:

         (a) Be designed with a volume 10 times the total quantity of wash water discharged during any 24-hour period

         (b) Location free from flooding

         (c) Outlet to be at the end opposite the inlet

         (d) Velocity to be dissipated at the inlet end

         (e) Where necessary, dikes, deflecting gutters or other means of diverting surface water so that it does not flow into the lagoon

         (f) A minimum usable depth of 5 feet

         (g) Adequate freeboard

(h) Adjustable weirs/decanting devices for decanting

(i) Effluent sampling point

(j) Adequate safety provisions, such as fencing

(k) A minimum of two lagoons

(l) Accessibility for residual removal (by providing ramps)

(m) Existing lagoons should be lined if located in the Zone I of a groundwater source or Zone A of a surface water source. All new lagoons within a Zone I of a groundwater source or a Zone A of a surface water source shall be lined.

(n) An NPDES permit shall be required for the effluent of any lagoon that discharges to surface water.

(o) A groundwater discharge permit may be required by the MassDEP or appropriate wastewater permitting authority.

(2) Sanitary Sewer Discharge - When residuals are discharged to sanitary sewers, a holding or receiving basin is recommended to allow settling of residuals and for the decanting and recycling of supernatant waters. Approval from the POTW receiving the flow from the sewer may be required for the discharge of water treatment residuals to a sanitary sewer. The amount of material to be discharged to a sewer system and the authority to do so should be determined prior to the design phase of the facility.

(3) Residuals Holding Tanks - If recycling supernatant to the head of a water treatment, the plant must comply with 5.10.2.4.a.

(4) Mechanical Concentration - A pilot study is required before the design of a mechanical dewatering installation unless it can be demonstrated that sufficient information exists to allow the proposed system to be properly designed.

4. Residuals Supernatant/Filter Backwash Water

a. Recycling:

(1) General
Returning a residuals supernatant stream or filter backwash water to a water treatment plant's primary treatment process is a conditionally acceptable alternative for both ground and surface water treatment plants.

(a) All recycled flows shall be metered and the chemical feed rates adjusted to reflect the recycle flow rate.

(b) A variable pumping rate (approximately five percent of treatment rate) that provides a continuous flow based on the treatment rate of the plant is preferable. If the recycle return rate is high (compared to the treatment rate), hydraulic surges within the facility may result causing a significant disruption of the treatment process and ultimately leading to a degradation of the finished water quality. The recycle return rate should be low compared to actual treatment rate to minimize hydraulic surges.

(c) When proposing recycling, consideration shall be given to adjustment of chemical feed practices during recycling, hydraulic surges, and potential to disrupt the chemistry of the treatment process or impair the treatment performance.

(2) All Treatment Plants: Facilities that recycle residuals supernatant and/ or filter backwash water from open lagoons or open basins (tanks) shall be subject to the Surface Water Treatment Rule, the Filter Backwash Recycling Rule if applicable and MassDEP's Design Guidelines for surface water treatment plants.

(3) Surface Water/Groundwater Under Influence Treatment Plants: Facilities treating surface water that recycle backwash water shall conform to the requirements of the Filter Backwash Recycling Rule.

(4) For the purpose of compliance with the Filter Backwash Recycling Rule, the recycling of any flow shall be returned to a point prior to the addition of any chemical feed or other treatment used to meet the removal/inactivation requirements of the Surface Water Treatment Rules, unless otherwise approved by MassDEP.

b. Disposal to ground and surface waters

(1) An NPDES permit will be required for discharging any lagoon effluent to surface water.

(2) A groundwater discharge permit may be required by MassDEP or appropriate wastewater permitting authority.

5. Filter Backwash Water Discharge

Filter backwash water may be discharged to one or more of the following:

a. Lagoons /Freeze-Dry Beds

b. Sewer (permits required)

c. Equalization Tanks

d. Surface or Groundwater (permits required)

e. Recycling

f. Sand Filters

6. Membrane Cleaning Water Disposal
   Wash water containing cleaning chemicals shall be discharged to a tight tank (holding tank), sewer, or other method as approved by MassDEP. For discharge to a tight tank a certification will be required; for discharge to a sewer, a permit will be required.

7. Radionuclide Waste

   PWS shall comply with the latest guidance from MassDEP, USEPA, Nuclear Regulatory Commission (NRC) and MA DPH Radiation Control Program as follows:

   a. For BATs (Best Available Technology) for radionuclide removal in drinking water see MassDEP 310 CMR 22.09A, Tables C, D, and E

   b. Calculations shall be performed to estimate the removal efficiency of the treatment process (radionuclide concentration of the backwash water and the residual left in the media).

   c. Exemption: A system is exempt from NRC and MADPH licensing if the radionuclide residual does not exceed .05% by weight. PWSs that are either treating for radionuclides or generating a radioactive residual as a result of other treatment, with a concentration less than .05% by weight must notify the MassDEP Drinking Water Program in writing. Notice must be provided within 15 days of making the determination and include supporting documentation and calculations.

   d. General License: A system must apply for and receive a general license if the treatment process generates 15 pounds or less of uranium or radium per month and not more than 150 pounds per year and exposes individuals to 100 mRem or less. Under the general license, disposal options are identified. These usually involve shipping media back to the media vendor. MA DPH Radiation Control Program issues general licenses.

      Specific License: A system shall apply for and receive a specific license if any treatment process exceeds the limits permitted under a general license or if eligible for a general license but the PWS does not apply for the license within the required time. MA DPH Radiation Control Program issues specific licenses.

   f. Discharge to Sewer: A system may apply to the local sewer commission for a permit to discharge to the sewer. Generally, sewer permits are limited by federal regulation at 3000 mg/L.

5.10.3 Final Disposal of Waste Residuals

Final disposal of residuals generated by a water treatment facility may be accomplished by one of the following methods provided the appropriate authority obtains the required approvals:

1. Landfill

2. Land applications

3. Reuse

4. Incineration

5. Sewage collection system

6. Wastewater facility

5.10.4 Approval of Water Treatment Facilities

Water treatment facilities requiring an NPDES Permit, a Sewer Connection/Extension Permit or Groundwater Discharge Permit shall not be approved to go on line until MassDEP issues the Permit(s).